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Naval Oceanographic and
Atmospheric Research Laboratory

Technical Note 131
August 1991

SEVERE WEATHER GUIDE MEDITERRANEAN PORTS

41. TUNIS

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ABSTRACT

This handbook for the port of Tunis, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

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ACKNOWLEDGMENTS

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CONTENTS

FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Atmospheric Directorate, Naval Oceanographic and Atmospheric Laboratory (NOARL), Monterey, to create products for direct application to Fleet Operations. The research was conducted in response to Commander Naval Oceanography Command (COMNAVOCEANCOM) requirements validated by the Chief of Naval Operations (OP-096).

As mentioned in the preface, the Mediterranean region is unique in that several areas exist where local winds can cause dangerous operating conditions. This handbook will provide the ship's captain with assistance in making decisions regarding the disposition of his ship when heavy winds and seas are encountered or forecast at various port locations.

Readers are urged to submit comments, suggestions for changes, deletions and/or additions to Naval Oceanography Command Center (NAVOCEANCOMCEN), Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to NOARL, Monterey for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

PORT INDEX

The following is a tentative prioritized list of Mediterranean Ports to be evaluated during the five-year period 1988-92, with ports grouped by expected year of the port study's publication. This list is subject to change as dictated by circumstances and periodic review. Computerized versions of these port guides are available for those ports with an asterisk (*). Contact the Atmospheric Directorate, NOARL, Monterey or NOCC Rota for IBM compatable floppy disk copies.

NO.	PORT
*1	GAETA, ITALY
*2	NAPLES, ITALY
*3	CATANIA, ITALY
*4	AUGUSTA BAY, ITALY
*5	CAGLIARI, ITALY
*6	LA MADDALENA, ITALY
7	MARSEILLE, FRANCE
8	TOULON, FRANCE
9	VILLEFRANCHE, FRANCE
10	MALAGA, SPAIN
11	NICE, FRANCE
12	CANNES, FRANCE
13	MONAÇO
14	ASHDOD, ISRAEL
15	HAIFA, ISRAEL
16	BARCELONA, SPAIN
17	PALMA, SPAIN
18	IBIZA, SPAIN
19	POLLENSA BAY, SPAIN
20	LIVORNO, ITALY
21	LA SPEZIA, ITALY
22	VENICE, ITALY
23	TRIESTE, ITALY
*24	CARTAGENA, SPAIN
*25	VALENCIA, SPAIN
*26	SAN REMO, ITALY
*27	GENOA, ITALY
*28	PORTO TORRES, ITALY
*29	PALERMO, ITALY
*30	MESSINA, ITALY
*31	TAORMINA, ITALY

1991	PORT
*32	TARANTO, ITALY
*33	TANGIER, MOROCCO
*34	BENIDORM, SPAIN
*35	ROTA, SPAIN
*36	LIMASSOL, CYPRUS
*37	LARNACA, CYPRUS
*38	ALEXANDRIA, EGYPT
*39	PORT SAID, EGYPT
*40	BIZERTE, TUNISIA
*41	TUNIS, TUNISIA
*42	SOUSSE, TUNISIA
*43	SFAX, TUNISIA
*44	SOUDA BAY, CRETE
	VALETTA, MALTA
	PIRAEUS, GREECE

1992	PORT
	KALAMATA, GREECE
	CORFU, GREECE
	KITHIRA, GREECE
	THESSALONIKI, GREECE

DELAYED INDEFINITELY

ALGIERS, ALGERIA
ISKENDERUN, TURKEY
IZMIR, TURKEY
ISTANBUL, TURKEY
ANTALYA, TURKEY
GOLCUK, TURKEY

PREFACE

Environmental phenomena such as strong winds, high waves, restrictions to visibility and thunderstorms can be hazardous to critical Fleet operations. The cause and effect of several of these phenomena are unique to the Mediterranean region and some prior knowledge of their characteristics would be helpful to ship's captains. The intent of this publication is to provide guidance to the captains for assistance in decision making.

The Mediterranean Sea region is an area where complicated topographical features influence weather patterns. Katabatic winds will flow through restricted mountain gaps or valleys and, as a result of the venturi effect, strengthen to storm intensity in a short period of time. As these winds exit and flow over port regions and coastal areas, anchored ships with large 'sail areas' may be blown aground. Also, hazardous sea state conditions are created, posing a danger for small boats ferrying personnel to and from port. At the same time, adjacent areas may be relatively calm. A glance at current weather charts may not always reveal the causes for these local effects which vary drastically from point to point.

Because of the irregular coast line and numerous islands in the Mediterranean, swell can be refracted around such barriers and come from directions which vary greatly with the wind. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for tendered vessels. Moderate to heavy swell may also propagate outward in advance of a storm resulting in uncomfortable and sometimes dangerous conditions, especially during tending, refueling and boating operations.

This handbook addresses the various weather conditions, their local cause and effect and suggests some evasive action to be taken if necessary. Most of the major ports in the Mediterranean will be covered in the handbook. A priority list, established by the Sixth Fleet, exists for the port studies conducted and this list will be followed as closely as possible in terms of scheduling publications.

RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	PAGE NUMBER	ENTERED BY

1. GENERAL GUIDANCE

1.1 DESIGN

This handbook is designed to provide ship captains with a ready reference on hazardous weather and wave conditions in selected Mediterranean harbors. Section 2, the captain's summary, is an abbreviated version of section 3, the general information section intended for staff planners and meteorologists. Once section 3 has been read, it is not necessary to read section 2.

1.1.1 Objectives

The basic objective is to provide ship captains with a concise reference of hazards to ship activities that are caused by environmental conditions in various Mediterranean harbors, and to offer suggestions for precautionary and/or evasive actions. A secondary objective is to provide adequate background information on such hazards so that operational forecasters, or other interested parties, can quickly gain the local knowledge that is necessary to ensure high quality forecasts.

1.1.2 Approach

Information on harbor conditions and hazards was accumulated in the following manner:

A. A literature search for reference material was performed.
B. Cruise reports were reviewed.
C. Navy personnel with current or previous area experience were interviewed.
D. A preliminary report was developed which included questions on various local conditions in specific harbors.
E. Port/harbor visits were made by NOARLW personnel; considerable information was obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained.
F. The cumulative information was reviewed, combined, and condensed for harbor studies.

1.1.3 Organization

The Handbook contains two sections for each harbor. The first section summarizes harbor conditions and is intended for use as a quick reference by ship captains, navigators, inport/at sea OOD's, and other interested personnel. This section contains:

A. a brief narrative summary of environmental hazards,
B. a table display of vessel location/situation, potential environmental hazard, effect-precautionary/evasion actions, and advance indicators of potential environmental hazards,
C. local wind wave conditions, and
D. tables depicting the wave conditions resulting from propagation of deep water swell into the harbor.

The swell propagation information includes percent occurrence, average duration, and the period of maximum wave energy within height ranges of greater than 3.3 feet and greater than 6.6 feet. The details on the generation of sea and swell information are provided in Appendix A.

The second section contains additional details and background information on seasonal hazardous conditions. This section is directed to personnel who have a need for additional insights on environmental hazards and related weather events.

1.2 CONTENTS OF SPECIFIC HARBOR STUDIES

This handbook specifically addresses potential wind and wave related hazards to ships operating in various Mediterranean ports utilized by the U.S. Navy. It does not contain general purpose climatology and/or comprehensive forecast rules for weather conditions of a more benign nature.

The contents are intended for use in both pre-visit planning and in situ problem solving by either mariners or environmentalists. Potential hazards related to both weather and waves are addressed. The oceanographic information includes some rather unique information relating to deep water swell propagating into harbor shallow water areas.

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested precautionary/evasive actions for various combinations of environmental threats and vessel location/situation are provided. Local indicators of environmental hazards and possible evasion techniques are summarized for various scenarios.

CAUTIONARY NOTE: In September 1985 Hurricane Gloria raked the Norfolk, VA area while several US Navy ships were anchored on the muddy bottom of Chesapeake Bay. One important fact was revealed during this incident: Most all ships frigate size and larger dragged anchor, some more than others, in winds of over 50 knots. As winds and waves increased, ships 'fell into' the wave troughs, BROADSIDE TO THE WIND and become difficult or impossible to control.

This was a rare instance in which several ships of recent design were exposed to the same storm and much effort was put into the documentation of lessons learned. Chief among these was the suggestion to evade at sea rather than remain anchored at port whenever winds of such intensity were forecast.

2. CAPTAIN'S SUMMARY

The Port of Tunis, Tunisia is located on the Mediterranean coast of North Africa at approximately 36°48'N 10°18'E (Figure 2-1).

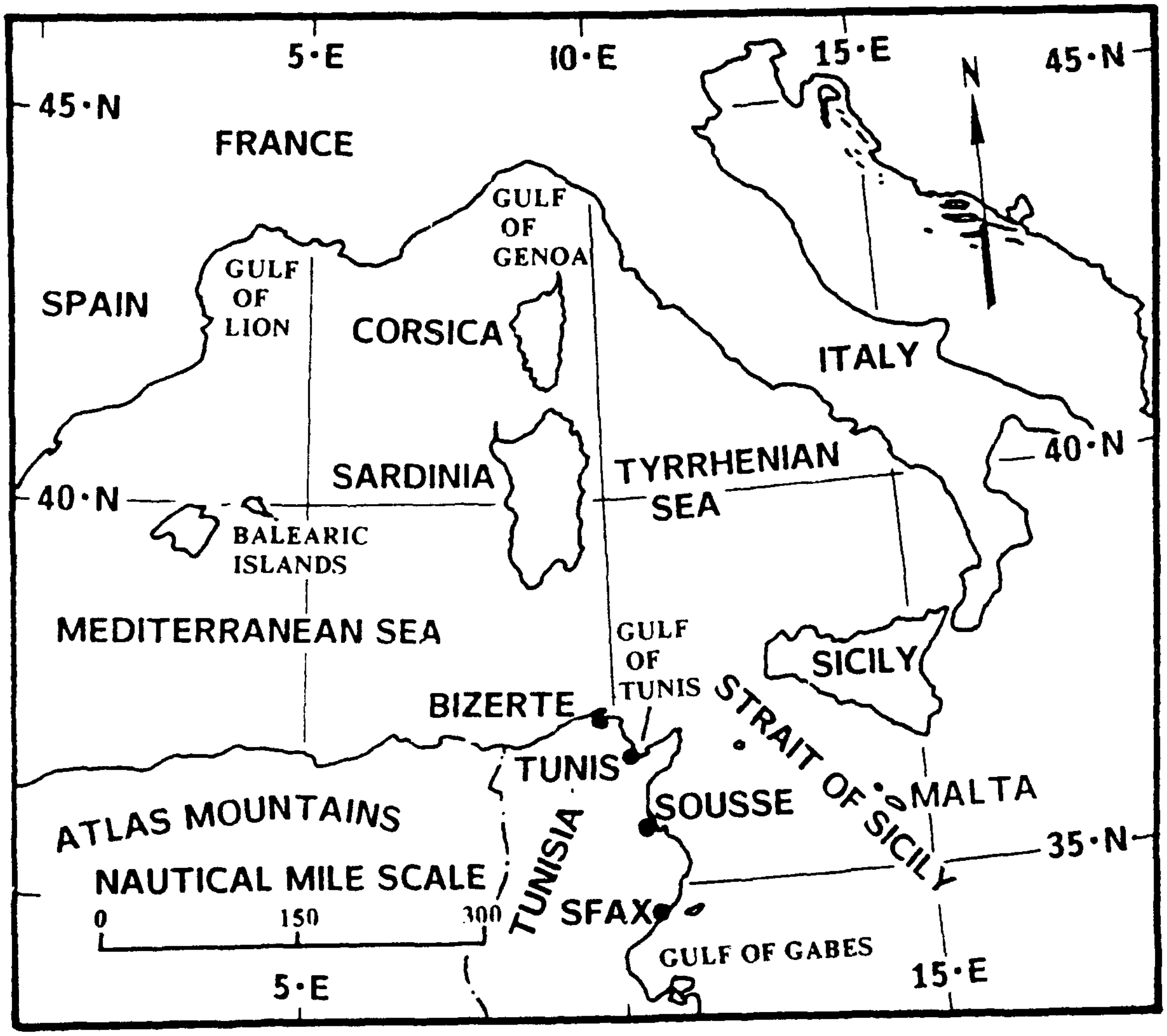

Figure 2-1. West and Central Mediterranean Sea.

Situated in the southwest corner of the Gulf of Tunis, the Port of Tunis is divided into two separate, distinct parts. The part addressed in this document is located at La Goulette, which is adjacent to Halq al Wadi at the east entrance to the Tunis Canal (Canal de Tunis). Tunis Canal is a 7 n mi long, narrow, dredged channel that extends between masonry embankments across Lake (Buhayrat) Tunis between La Goulette and Tunis (Figure 2-2). The artificial harbor located at the west end of the Tunis Canal adjacent to the city of Tunis is not included in this port evaluation.

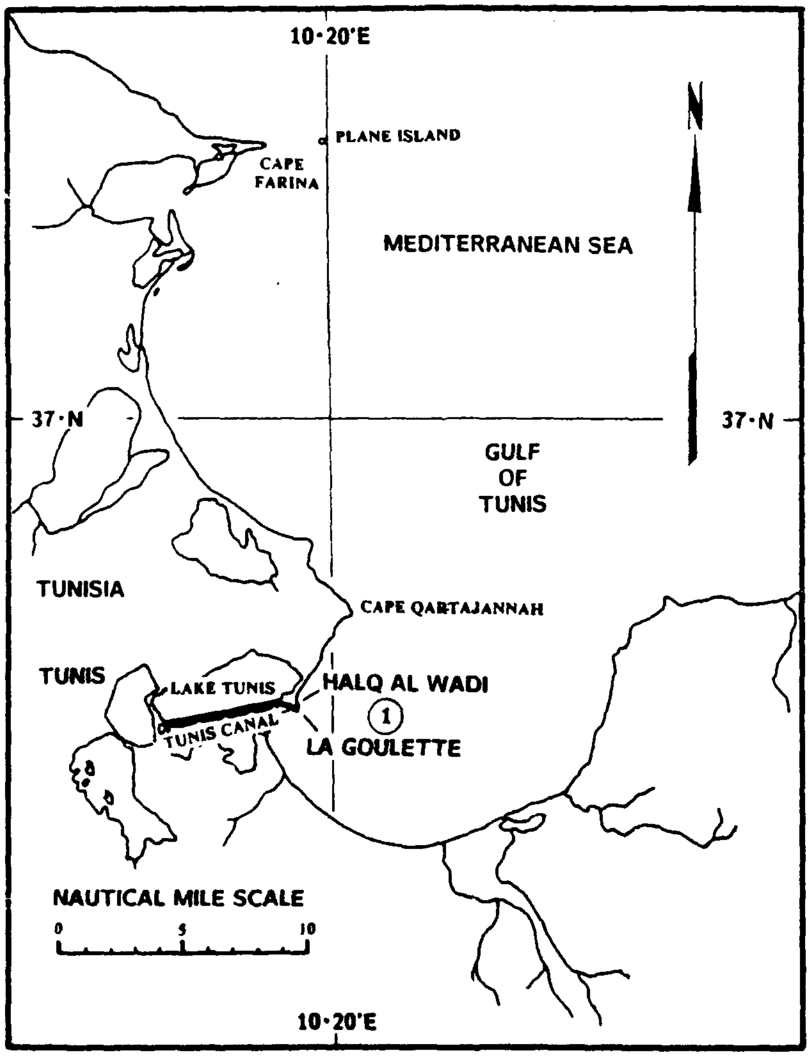

Figure 2-2. Approaches to the Port of Tunis, Tunisia.

Commercial port facilities in La Goulette can adequately accommodate approximately three vessels of up to 15,000 tons each along the north wharf, and two vessels along the south wharf (Figure 2-3). Vessels with a maximum draft of 21.5 ft (6.55 m) can be accommodated. Average depth of the basin is 33 ft (10 m). Ships are berthed for maximum use of wharf space.

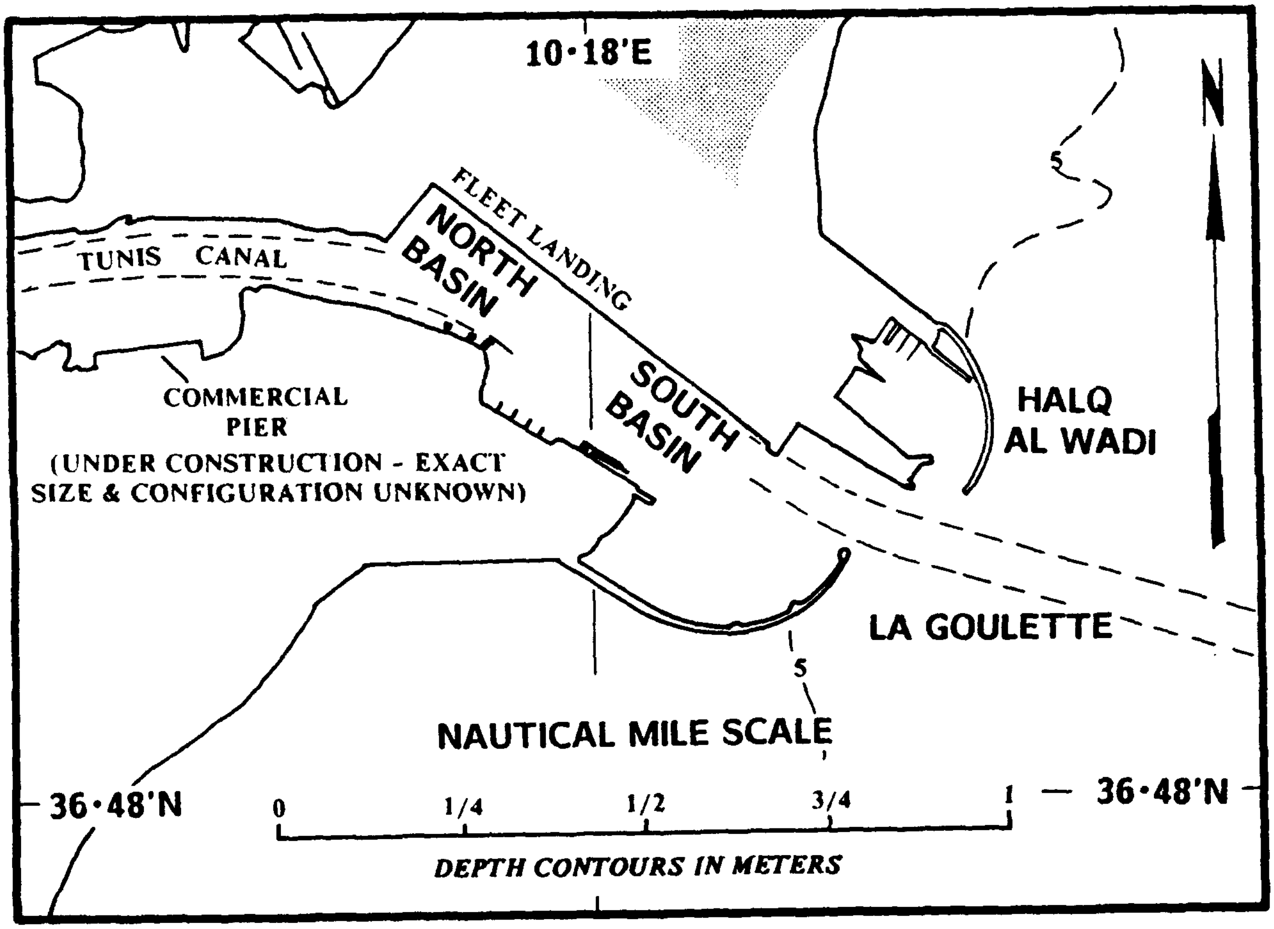

Figure 2-3. Port of Tunis (La Goulette), Tunisia.

The width of the north wharf makes it essential that ships which are moored starboard side to, be pulled out, moved straight back into the wider area of the turning basin (depth is 32 ft (9.8 m) and shallows quickly), and then be twisted around by tugs to transit down the channel. Daily harbor traffic from La Goulette to Tunis Canal passes close aboard (within 25 to 50 yd) of vessels berthed at the north wharf (FICEURLANT, 1985).

The narrow channel to La Goulette can be navigated safely by only one large vessel at a time. The turning basin is very small; a ship should not enter the channel until the ship ahead is berthed. FICEURLANT (1985) states that tugs in La Goulette basin push without lines rather than make up lines for pulling. Silting is a problem in the channel due to persistent easterly, summer winds.

The fleet landing is located on the north wharf, with the extreme western tip used as a flag landing. There is room for 3 or 4 boats at a time, but there are only 3 metal stanchions available. Wooden and rubber fenders are located every 15 ft (4.6 m). FICEURLANT (1985) states that boat landings were made at the Tunisian Naval Base inside the northern breakwater at 36°48'40"N 10°18'45"E in 1981.

Local authorities indicated that the primary anchorage is located 5 n mi due east of the entrance in depths to 42 ft (13 m), with good holding on a sand bottom. The <u>Port Directory</u> states that large vessels anchor about 0.5 n mi (0.8 km) northeast of the sea buoy in depths of 40 to 46 ft (12 to 14 m) on a sand bottom with good holding. Small vessels may anchor either north or south of the approach channel in depths of 23 to 30 ft (7 to 9 m), in the vicinity of buoys 4 and 5, provided they do not obstruct navigation in the entrance channel. In November 1983, anchorage was made by an AO at 37°46.9'N 10°22.9'E in 8 fm (14.5 m). Due to the AO's draft of 33 ft (10 m), the vessel could not approach closer than 5 n mi to La Goulette canal and the location of the fleet landing (FICEURLANT, 1985).

Local authorities state that the tidal range in the harbor is 1 ft (30 cm). Currents in the harbor are negligible and do not affect harbor operations. Current flow in the Gulf of Tunis is generally counter-clockwise. Currents in Tunis Canal do not exceed 1 kt (FICEURLANT, 1985).

Specific hazardous conditions, vessel situations, and suggested precautionary/evasive action scenarios are summarized in Table 2-1.

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Table 2-1. Summary of hazardous environmental conc

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL L SITUATION
1. <u>NE'ly winds/waves</u> - * Most common in winter and spring. * Possible in autumn. * Uncommon in summer. * Winds of 34-47 kt are possible. * Waves of 7-10 ft (2-3 m) may enter Gulf of Tunis.	<u>Advance warning</u>. * Any indication that a low pressure system in the Gulf of Genoa is starting to move SE. * N African low moving E into the Gulf of Gabes from S of the Atlas Mountains. <u>Duration</u>. * Once started, the wind should continue to blow until the low pressure center moves out of the Tyrrhenian Sea, or the N African low moves E away from Tunisia.	(1) <u>Moore La Gc</u> (2) <u>Anchc</u> (3) <u>Arriv depar</u> (4) <u>Small</u>
2. <u>NW'ly winds/waves</u> - Locally called gabale. * Most common in winter and spring. * Possible in autumn. * Uncommon in summer. * Winds of 34-47 kt are possible. * Swell may enter Gulf of Tunis and reflect off SE coast back to harbor entrance.	<u>Advance warning</u>. * Can be expected about 2 days after a strong mistral begins in the Gulf of Lion. <u>Duration</u>. * Will persist until mistral conditions in the Gulf of Lion abate. * Local rule for Sousse states that gale force NW winds will blow for either 3, 6 or 9 days. The same rationale may apply to Tunis.	(1) <u>Moore La Go</u> (2) <u>Ancho</u> (3) <u>Arriv depar</u> (4) <u>Small</u>

hazardous environmental conditions for the Port of Tunis, Tunisia

ƦS OF ·IAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
. that a low ·m in the Gulf .arting to move	(1) Moored - La Goulette.	(a) Little adverse effect in the harbor. * Ships should remain in port, and add/double mooring lines as necessary. * Sortie is not recommended.
moving E into ıbes from S of ıtains.	(2) Anchored.	(b) WORST CONDITION FOR THE ANCHORAGE. * Strong event may necessitate sortie to ride out heavy weather at sea. * Lesser event may only require anchoring with bow into swell using 2 anchors.
the wind ıe to blow pressure ɔut of the ı, or the N ɔves E away	(3) Arriving/ departing.	(c) WORST CONDITION FOR THE ANCHORAGE, BUT LITTLE ADVERSE EFFECT IN THE HARBOR. * Inbound vessels should consider remaining at sea until conditions in the port abate before entering. * Outbound vessels should get underway prior to wind onset or stay in port until conditions abate. * No nearby havens exist.
	(4) Small boats.	(d) No significant problems in the harbor. * Runs to/from the anchorage may have to be curtailed in a strong event.
: about 2 days mistral .ulf of Lion. ntil mistral the Gulf of	(1) Moored - La Goulette.	(a) Little adverse effect in the harbor. * Waves reflecting off SE coast of the Gulf of Tunis effect maneuvering in the entrance channel and could reach ships mcored to the N pier. * Ships should remain in port, and add/double mooring lines as necessary. * Sortie is not recommended.
Sousse states e NW winds either 3, 6 or ame rationale ınis.	(2) Anchored.	(b) Winds may affect ships in anchorage. * Ships should be able to remain in anchorage by using 2 anchors and anchoring with bow into swell. * If strong event dictates a sortie, shelter may be found N of Tunis in the lee of Cape Farina, or along the coast N of the Gulf of Hammamet.
	(3) Arriving/ departing.	(c) NW'ly swell reflects off SE coast of the Gulf of Tunis back to entrance channel. * Inbound and outbound vessels may encounter steerage difficulties in the entrance channel.
	(4) Small boats.	(d) No significant problems in the harbor. * Runs to/from the anchorage may have to be curtailed in a strong event.

Table 2-1. (Continued)

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOC SITUATION A
3. E'ly winds - Locally called levante. * Strong events most common in autumn, winter and spring but may occur any month.	Advance warning. * Any synoptic situation that results in high pressure N of Tunis with relatively lower pressure to the S.	(1) Moored - La Goule (2) Anchored (3) Arriving departin (4) Small bo

Table 2-1. (Continued)

...RS OF HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
... situation that ...high pressure N ...h relatively ...re to the S.	(1) Moored - La Goulette.	(a) Little effect in the harbor. * Ships should remain in port, and add/double mooring lines as necessary.
	(2) Anchored.	(b) Wind may affect ships in anchorage. * A strong event may dictate that ship move to the E part of the Gulf of Tunis and take advantage of the lee of the peninsula E of the port.
	(3) Arriving/ departing.	(c) No major problems are identified for inbound/outbound units. * A strong event may dictate that ships inbound to the anchorage move to the E part of the Gulf of Tunis to take advantage of the lee of the peninsula E of the port.
	(4) Small boats.	(d) No significant problems in the harbor. * Runs to/from the anchorage may have to be curtailed in a strong event.

Shallow water wave conditions in response to deep water swell entering the area have been computed for the anchorage area. The anchorage area is designated as Point 1 in figure 2-2 and has a depth of about 45 ft (14 m).

Table 2-2 provides the height ratio and direction of shallow water waves to expect at Point 1 when the deep water wave conditions are known. The Tunis harbor anchorage conditions are found by entering Table 2-2 with the forecast or known deep water wave direction and period. In the following example., the height is determined by multiplying the deep water height (8 ft) by the ratio of shallow to deep height (.6).

Example: Use of Table 2-2 for Tunis Harbor Anchorage
Deep water wave forecast as provided by a forecast center or a reported/observed deep water wave condition: 12 feet, 12 seconds, from 360°
The expected wave condition at the Tunis anchorage as determined from Table 2-2: 7 feet, 12 seconds, from 020°

NOTE: Wave periods are a conservative property and, therefore, remain constant when waves move from deep to shallow water, but speed, height, and steepness change.

Table 2-2. Shallow water wave directions and relative height conditions versus deep water period and direction (see Figure 2-2 for location of the point).

FORMAT: Shallow Water Direction
Wave Height Ratio: (Shallow Water/Deep Water)

TUNIS POINT 1: Anchorage Depth 45 ft

Period (sec)	6	8	10	12	14
Deep Water Direction	Shallow Water Direction and Height Ratio				
360°*	360° .5	360° .5	010° .6	020° .6	020° .5
030°	030° 1.0	030° .9	030° .8	035° .8	035° .8
060°	060° .5	055° .4	050° .2	045° .15	035° .2

*Note: Mistral generated northwesterly waves over the open Mediterranean Sea must be refracted to become northerly swell after entering the Gulf of Tunis in order to reach the anchorage area.

Climatological factors of shallow water waves, as described by percent occurrence, average duration, and period of maximum energy (period at which the most energy is focused for a given height), are given in Table 2-3. See Appendix A for discussion of wave spectrum and energy distribution. These data are provided by season for two ranges of heights: greater than 3.3 ft (1 m) and greater than 6.6 ft (2 m).

Table 2-3. Shallow water climatology as determined from deep water wave propagation. Percent occurrence, average duration or persistence, and wave period of maximum energy for wave height ranges of greater than 3.3 ft (1 m) and greater than 6.6 ft (2 m) by climatological season.

TUNIS POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	42	22	24	28
Average Duration (hr)	22	16	32	22
Period Max Energy (sec)	6	6	6	6
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	14	3	1	5
Average Duration (hr)	16	7	8	18
Period Max Energy (sec)	6*	6	6	6

*Note that in winter extreme wave heights of 13 to 16 ft at about 12-second periods occur during strong mistral events.

Local wind wave conditions based on the JONSWAP model are provided in Table 2-4 for a range of fetch lengths and wind speeds. The time to reach the fetch limited height assumes an initial flat ocean. With a pre-existing wave height, the times are shorter. See Appendix A for discussion of wind waves and the JONSWAP model.

Table 2-4. Tunis. Local wind waves for fetch limited conditions (based on JONSWAP model).

Format: height (feet)/period (seconds)
time (hours) to reach fetch limited height

Fetch Length (n mi)	Local Wind Speed (kt) 18	24	30	36	42
5	<2 ft	2/3-4 1	2-3/3-4 1	3/3-4 1-2	3-4/3-4 1
10	2/3-4 1-2	3/3-4 2	3-4/4 2	4/4-5 1-2	5/5 1-2
15	2-3/4 2	3-4/4 2	4/4-5 2	5/5 2	6/5 2
20	3/4-5 2-3	4/4-5 3	5/5 3	6/5-6 3-4	7/5-6 3
25	3-4/4-5 3	4/5 3	5-6/5 3	6-7/6 3	7-8/6 3
30	4/4-5 3	5/5-6 4	6/6 3-4	7/6 3-4	8/6-7 3

Example: Small boat wave forecasts for a location that has a 5 n mi limited fetch to the east (based on the assumption that swell is not a limiting condition).

Forecast for Tomorrow:

Time	Wind (Forecast)	Waves (Table 2-4)
prior to 1000 LST	E 8-12 kt	< 2 ft
1000 to 1400	E 22-26 kt	2 ft at 3-4 sec by 1100
1400 to 1900	E 34-38 kt	building to 3 ft at 3-4 sec by 1500

Interpretation: Assuming that the limiting factor is waves greater than 3 feet, small boat operations will become marginal by 1500.

SEASONAL SUMMARY OF HAZARDOUS WEATHER CONDITIONS

WINTER (November through February)

* Northeast wind and waves.
  * Worst conditions for the port.
  * Ships in harbor should remain there.
  * Ships in anchorage may have to sortie.
    * No nearby havens exist.
* Northwest winds and waves.
  * Usually occurs 2 days after onset of a strong mistral in Gulf of Lion.
  * Northwest swell reflects off southeast coast of Gulf of Tunis, causing steerage problems for ships in the entrance channel.
* Easterly winds.
  * If a strong event occurs, shelter for ships in the anchorage may be found in the lee of the peninsula east of Tunis.

SPRING (March through May)

* Northeast and northwest winds and waves continue to be a threat to the port until late in the season.

SUMMER (June through September)

* Summer weather is generally settled, hot, and dry.

AUTUMN (October)

* Short transitional season with winter-like weather returning by month's end.

NOTE: For more detailed information on hazardous weather conditions, see previous table 2-1 in this section and Hazardous Weather Summary in Section 3.

REFERENCES

FICEURLANT, 1985 (Reissued 1987): Port Directory for Tunis, Tunisia. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

PORT VISIT INFORMATION

JANUARY 1990. NOARL Meteorologists R. Fett and Lieutenant M. Evans, U.S. Navy, met with Port Captain Mr. Mohamed Azzabou to obtain much of the information included in this port evaluation.

3. GENERAL INFORMATION

This section is intended for Fleet meteorologists/oceanographers and staff planners. Paragraph 3.5 provides a general discussion of hazards and table 3-4 provides a summary of vessel locations/situations, potential hazards, effect-precautionary/evasive actions, and advance indicators and other information about potential hazards by season.

3.1 Geographic Location

The Port of Tunis, Tunisia is located on the Mediterranean coast of North Africa at approximately 36°48'N 10°18'E (Figure 3-1).

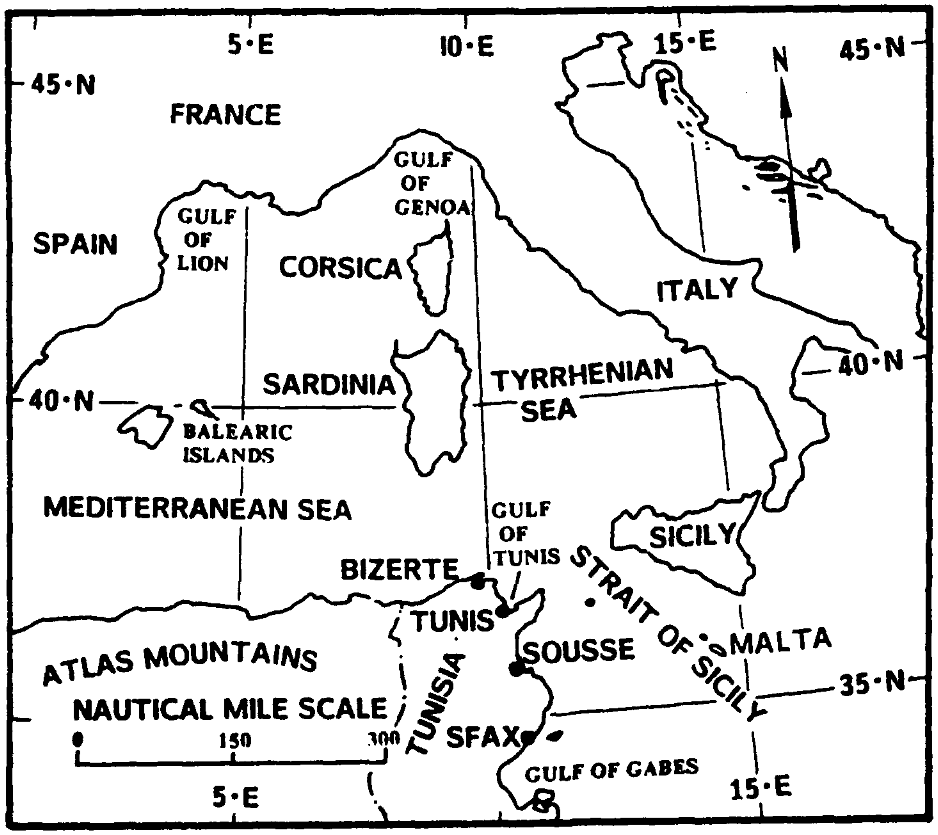

Figure 3-1. West and Central Mediterranean Sea.

Situated in the southwest corner of the Gulf of Tunis, the Port of Tunis is divided into two separate, distinct parts. The part addressed in this document is located at La Goulette, which is adjacent to Halq al Wadi at the east entrance to the Tunis Canal (Canal de Tunis). Tunis Canal is a 7 n mi long, narrow, dredged channel that extends between masonry embankments across Lake (Buhayrat) Tunis between La Goulette and Tunis (Figure 3-2). The artificial harbor located at the west end of the Tunis Canal adjacent to the city of Tunis is not included in this port evaluation.

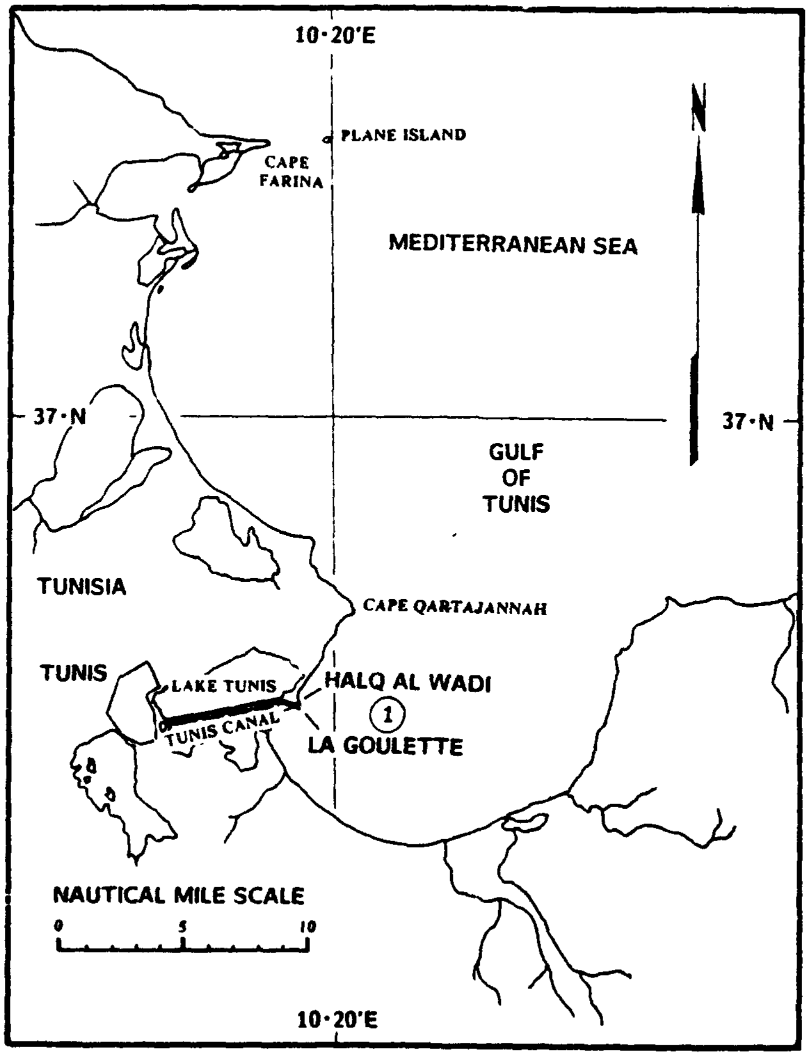

Figure 3-2. Approaches to the Port of Tunis, Tunisia.

Commercial port facilities in La Goulette can adequately accommodate approximately three vessels of up to 15,000 tons each along the north wharf, and two vessels along the south wharf (Figure 3-3). Average depth of the basin is 33 ft (10 m). Ships are berthed for maximum use of wharf space.

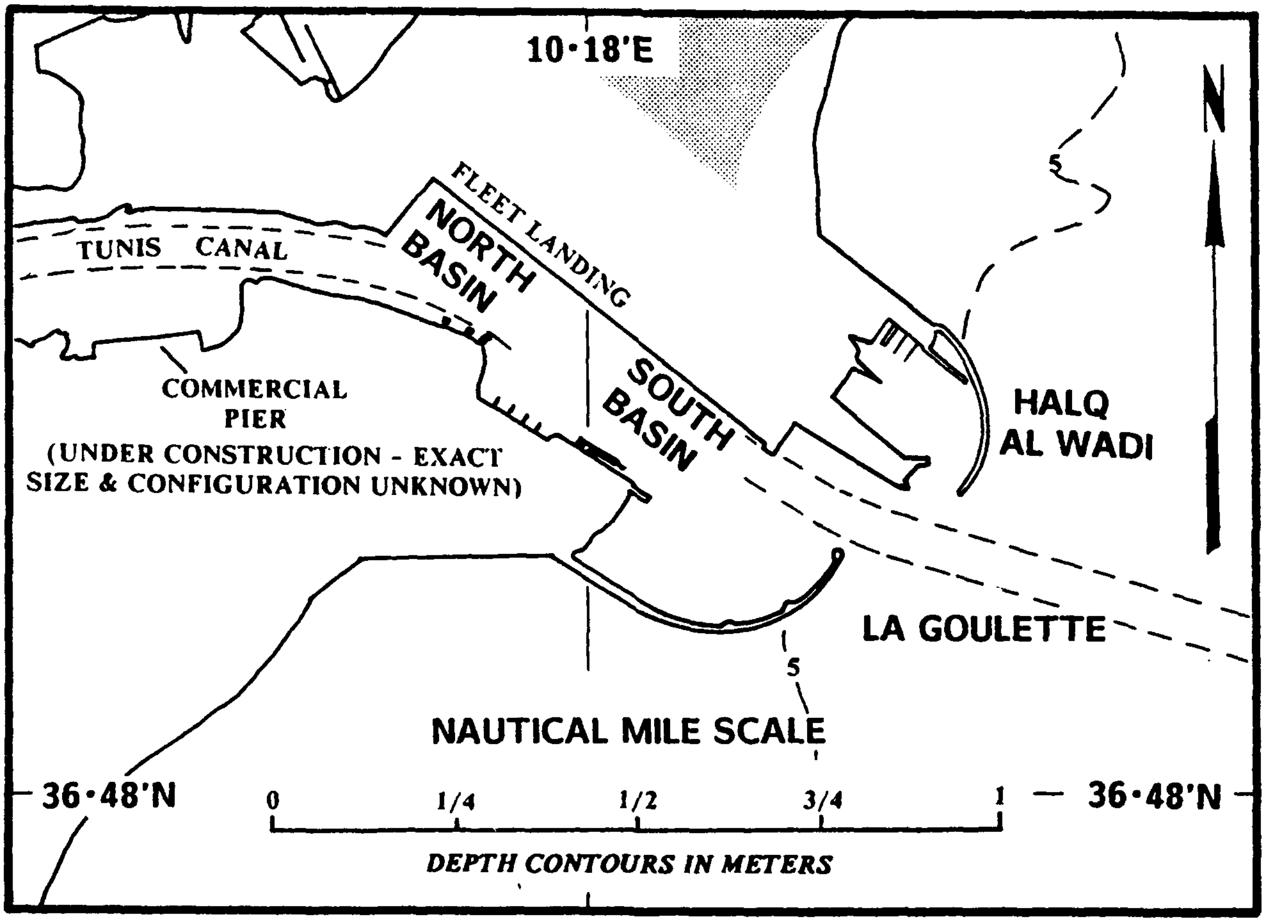

Figure 3-3. Port of Tunis (La Goulette), Tunisia.

The width of the north wharf makes it essential that ships which are moored starboard side to, be pulled out, moved straight back into the wider area of the turning basin (depth is 32 ft (9.8 m) and shallows quickly), and then be twisted around by tugs to transit down the channel. Daily harbor traffic from La Goulette to Tunis Canal passes close aboard (within 25 to 50 yd) of vessels berthed at the north wharf (FICEURLANT, 1985).

The narrow channel to La Goulette can be navigated safely by only one large vessel at a time. Channel depth was reported to be 28 ft (8.5 m) in 1981. The turning basin is very small; a ship should not enter the channel until the ship ahead is berthed. FICEURLANT (1985) states that tugs in La Goulette basin push without lines rather than make up lines for pulling. Silting is a problem in the channel due to persistent, easterly, summer winds.

The fleet landing is located on the north wharf, with the extreme western tip used as a flag landing. There is room for 3 or 4 boats at a time, but there are only 3 metal stanchions available. Wooden and rubber fenders are located every 15 ft (4.6 m), and lighting is available. FICEURLANT (1985) states that boat landings were made at the Tunisian Naval Base inside the northern breakwater at 36°48'40"N 10°18'45"E in 1981.

Local authorities indicated that the primary anchorage is located 5 n mi due east of the entrance in depths to 42 ft (13 m), with good holding on a sand bottom. The Port Directory states that anchorages in the port roads are safe except during strong winds and heavy seas from the north or northeast. Deep draft vessels at anchor in the open roadstead may experience considerable wave/swell action if the wind backs to the south with prevailing swells are from the north. Large vessels anchor about 0.5 n mi (0.8 km) northeast of the sea buoy in depths of 40 to 46 ft (12 to 14 m) on a sand bottom with good holding. Small vessels may anchor either north or south of the approach channel in depths of 23 to 30 ft (7 to 9 m), in the vicinity of buoys 4 and 5, provided they do not obstruct navigation in the entrance channel.

In November 1983, anchorage was made by an AO at 37°46.9'N 10°22.9'E in 8 fm (14.5 m). Due to the AO's draft of 33 ft (10 m), the vessel could not approach closer than 5 n mi to La Goulette and the fleet landing (FICEURLANT, 1985).

3.2 Qualitative Evaluation of the Port of Tunis

The port facilities at La Goulette offer limited protection from most hazardous weather conditions. Local authorities state that ships which are already in port should remain there if high winds are expected. The most bothersome weather conditions at the port are caused by strong northeasterly winds which may reach 34-47 kt (force 8-9) and be accompanied by waves of 7-10 ft (2-3 m). Entry and departure of the harbor may be restricted during strong northeasterly winds, and ships in the anchorage have had to sortie.

Strong northwesterly winds, which may reach gale force (34-47 kt, force 8-9) in winter, generate swell which reflects off the southeast coast of the southern portion of the Gulf of Tunis, causing steerage problems for ships in the channel.

3.3 Currents and Tides

Local authorities state that the tidal range in the harbor is 1 ft (30 cm). Currents in the harbor are negligible and do not affect harbor operations.

Current flow in the Gulf of Tunis is generally counterclockwise. Currents in Tunis Canal do not exceed 1 kt (FICEURLANT, 1985).

3.4 Visibility

Haze and, at times, blowing sand sometimes restricts visibility. Intermittent morning fog, which normally burns off by 1000L, may occur during spring.

3.5 Hazardous Conditions

Specific hazardous weather scenarios adversely impact the port at La Goulette. Northeasterly winds, most commonly caused by low pressure systems in the Tyrrhenian Sea, generate waves and swell which directly impact ships in the anchorage and have the potential to impact ships in the harbor. Northwesterly winds, most commonly caused by downstream effects of mistral events in the Gulf of Lion, generate swell which reflects off the southeast coast of the Gulf of Tunis, causing steerage problems for ships in the entrance channel.

Although uncommon, storms having tropical characteristics with fully developed eyes have been observed on at least three occasions in the Mediterranean Basin. On the latter occasion, September 1983, the storm moved northwest from the Gulf of Gabes (Figure 3-1), through the Straits of Sicily, along the east coast of Sardinia, and into the Gulf of Genoa. While the wind speeds at Tunis are not known, winds of 100 kt were observed near the eye. While the probability of such a storm striking Tunis is very low, the forecaster must be aware of the possibility.

Tunis receives an average of 16.3 inches of rain during an average year. Figure 3-4 shows the annual distribution by month. Thunderstorms at Tunis are not very strong and normally have little effect on marine operations.

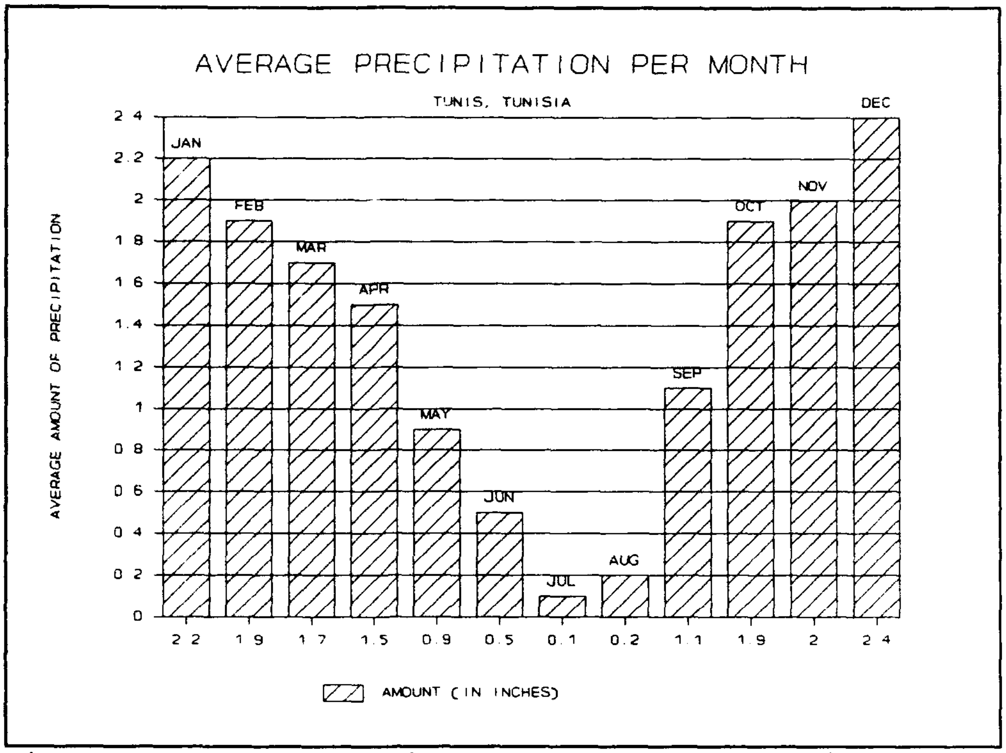

Figure 3-4. Precipitation. (After Hydrographic Department, 1963.)

A seasonal summary of various known environmental hazards that may be encountered in the Port of Tunis at La Goulette follows.

A. Winter (November through February)

According to the Port Directory for Tunis, Tunisia, published by Fleet Intelligence Center, Europe and Atlantic, Norfolk, VA, prevailing winds at Tunis are northerly during the winter. However, a 5-year record of wind directions compiled at a location some 6 n mi west of Tunis (36°48'N 10°10'E) and included in Mediterranean Pilot, Volume 1 (1963), shows that the predominant direction during the 4-month winter season ranges from southwest clockwise to northwest over 50% of the time for local times of 0600 and 1200. Directions were independent of speed in the summary.

Local authorities state that winds from the north quadrant cause the worst conditions for the port. As mentioned in section 3.2 above, the port is adversely affected by winds from northeast and northwest, and winds from those directions may result in steerage problems for ships in the channel. As discussed below, winds from the north quadrant may have different causes.

The primary cause of strong northeasterly winds, the most bothersome weather problem for the port, is a low pressure system in the Tyrrhenian Sea. While some low pressure systems form or intensify over the Tyrrhenian Sea, most systems are transitory after first forming near the Gulf of Genoa. A secondary potential cause of north to northeasterly winds at Tunis is a North African low pressure system which passes south of Tunis. The primary cause of strong northwesterly winds is a mistral event over the Gulf of Lion on the southeast coast of France.

Brody and Nestor's Regional Forecasting Aids for the Mediterranean Basin thoroughly discusses Genoa cyclones, North African lows, and mistrals. To enable the forecaster visiting Tunis to better understand the threat of the winds caused by these phenomena, the following information is excerpted from Brody and Nestor's document.

> Genoa cyclones. Genoa cyclones are low pressure systems which develop south of the Alps and are found over the Gulf of Genoa, Ligurian Sea, Po Valley and northern Adriatic Sea.
>
> Development factors. Several factors that have special relevance in the development of depressions south of the Alps are:
>
> (1) The thermal contrast between land and sea.
>
> (2) Interaction between the polar front jet stream and the subtropical jet stream.

(3) Effect of northerly flow over the Alps, enhancing cyclogenetic activity along the southern slopes.

(4) Effect of the concave curvature of the southern slopes of the Alps, enhancing cyclonic formation.

Development climatology. Genoa cyclogenesis can occur during all seasons, although the region of maximum cyclogenesis is located farther south in winter than in summer. The maximum density moves from the relatively warm water of the Gulf of Genoa during the winter to the hot land regions of the Po Valley during the summer.

Whether the cyclogenesis is initiated near the Gulf of Genoa or farther east near the Gulf of Venice depends on the amount of cold air penetrating the Po Valley from the northeast. If there is little or no cold air from the northeast entering the Po Valley, cyclogenesis will probably take place in the Gulf of Venice. Otherwise, the cyclogenesis will take place in its usual position to the west near the Gulf of Genoa.

Cyclone movement. A majority of Genoa cyclones either remain stationary, or at least leave a residual trough, south of the Alps throughout their life history. Two main tracks are favored: (1) If strong southwesterly flow aloft exists, the favored track is northeasterly to north-northeasterly across the Alps, or (2) if a strong anticyclone exists over the Balkans, Turkey and the Black Sea, the favored track is southeasterly near the northern border of the Mediterranean Sea. It is the latter track that would move the low across the Tyrrhenian Sea and produce northeasterly winds at Tunis.

It should be noted that even after the primary low has moved out of the Tyrrhenian Sea-central Mediterranean area, if a residual trough remains south of the Alps, new centers can develop and occasionally move southeastward along the west coast of Italy. Another common occurrence is for a Genoa cyclone, which has been moving southeastward, to become stationary just to the west of southern Italy. If this happens, a new center will usually develop to the east over the Ionian Sea.

Along the west coast of Italy, the strongest winds occur when the low moves off to the southeast. Gale force northeasterlies are common under these conditions. Although the strongest winds may not reach Tunis, the situation could result in gale force winds at the port.

North African Lows. Although not mentioned by local authorities, another potential source of strong northeasterly winds at Tunis is a transient North African low pressure system.

North African lows develop over the desert region south of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying northeast-southwest, producing a deep south-westerly flow over northwest Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range.

The lows which have the potential to produce strong northeasterly winds at Tunis follow an eastward track south of the Atlas mountains before moving over the Mediterranean Sea across the coast of Tunisia at or near the Gulf of Gabes. When North African lows occur south of the Atlas Mountains, strong easterly to southeasterly winds are likely over the southern Mediterranean and will result in high seas in the Strait of Sicily.

A North African low is most likely to form over Tunisia when the long-wave trough is oriented northeast-southwest across the Tyrrhenian Sea. Cold continental polar air will be advected in from eastern Europe and a cold pocket of air (-25°C at 500 mb) will form between Sardinia, Sicily and Tunisia. The subtropical jet also will be evident over North Africa. Wind speeds at 500 mb over Tunisia and Libya will be 55 kt or more.

The speed of movement with these systems is related to the time of year in which they develop. During late autumn and early winter, lows moving out of this area are noted for their extremely slow movement due to their association with a cut-off low aloft.

During late winter and early spring, as the number of North African cyclones increases, North Africa becomes the primary cyclogenesis area for the region. Unlike lows developing early in the winter, these lows are generally associated with open, short wave troughs. They produce little precipitation, but frequently produce high winds in close proximity to their centers. Their increased speed of movement compared with the early winter systems also make them unique. Some lows have been noted to move eastward out of North Africa at 40 to 50 kt. With the scarcity of reports along the cyclogenesis area, the use of satellite data over the region may be the only clue to the presence of a developing low.

Mistral. The mistral is the primary weather phenomenon associated with the Genoa low. Although mistral conditions can develop locally along the south coast of France, major Genoa cyclogenesis is necessary for an extensive mistral to occur. Even after the Genoa low has moved eastward, the mistral will continue in association with a residual trough to the south of the Alps.

The mistral is a cold, strong northwesterly to north-northeasterly offshore wind along part or all of the coast of the Gulf of Lion. Its influence occasionally extends beyond the Gulf of Lion to affect the weather of the entire Mediterranean basin.

The mistral is the result of a combination of the following factors:

(1) The basic circulation that creates a pressure gradient from west to east along the coast of southern France. This pressure gradient is normally associated with Genoa cyclogenesis.

(2) A fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the southern coast of France and thus increasing the wind speed.

(3) A jet-effect wind increase caused by the orographic configuration of the coastline. This phenomenon is observed at the entrance to major mountain gaps such as the Carcassonne Gap, Rhone Valley, and Durance Valley. It is also observed in the Strait of Bonifacio between Corsica and Sardinia.

(4) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land).

Mistral wind speeds often exceed 40 kt and occasionally have reached 100 kt in gusts along the coastal region from Marseille to

Toulon. Over the open water in the Gulf of Lion, mistral wind speeds locally greater than 40 kt occurred in nearly 8% of total observations.

The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing southeastward. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as North Africa, Sicily and Malta. Although the mistral is prevalent during all seasons, severe cases are most common during winter and spring.

Weather associated with mistral events is generally good near the mistral source, but as the cold air moves out over the warmer water, convective cloudiness increases. Very poor atmospheric visibilities also have been reported up to a height of 98 ft (30 m) during cases of extremely strong mistrals because of a layer of spray that extends above the water surface.

Local authorities state that easterly winds do not pose much of a threat to the Port of Tunis, but that possible lee shelter for ships in the anchorage exists in the lee of the peninsula to the east of the Gulf of Tunis. The following scenario of an actual event which brought strong easterly winds to the area is detailed to enable the meteorologist to better understand the potential for strong easterly winds in the area.

The Port Directory states that formation of a North African low in the mountains south of Tunis will result in rough weather in the roadstead with very little warning.

COMSIXTHFLT ltr 3140 Ser N312/003 (4 Jan 1990) addresses a specific weather event that took place on Malta (Figure 3-1) during 30 November-3 December 1989, the period of the well publicized Bush-Gorbachev talks. Although Malta is located on the eastern end of the Strait of Sicily about 220 n mi east-southeast of Tunis, the general weather scenario was one which would result in easterly conditions at Tunis. A résumé follows.

The USS Belknap was anchored in "Pretty Bay," Marsaxlokk, Malta from 26 November through 4 December 1989. The Soviet Navy cruiser, Slava, anchored about 500 yds southeast of Belknap on 28 November. The synoptic situation that caused the "Malta Meeting storm" was a classic "Gregale" existing in conjunction with an Adriatic and Aegean Bora as defined in Chapter V, paragraph 2.4 of Brody and Nestor (1980). A strong omega block dominated the European weather pattern from late November through the period of the Bush-Gorbachev meetings on 2-3 December. A strong ridge with 500 mb height maximum centered near Austria/ Czechoslovakia separated a cut-off low west of the Iberian Peninsula from a major long-wave trough over the western Soviet Union. A ridge of high pressure extended south across Italy and the Straits of Sicily from the center over the continent. Winds at Malta were east-southeasterly about 20 kt on 29 and 30 November.

A short-wave trough and jet max rotating around the eastern Europe long-wave trough moved south across Italy on 30 November/1 December. At the same time, a weak Tunisian low formed south of the Atlas mountains and moved east to the Gulf of Gabes. When it reached the water on 1 December, it intensified in response to the energy source of the warm water and the approaching short wave. About 020230Z winds backed to northeast and increased to 28-30 kt. Belknap dragged her stern anchor and the Slava dragged her stern buoy.

The low moved south of Malta and pressure began to rise at 020000Z. However, infrared pictures from METEOSAT showed an indication of a second circulation in the Gulf of Gabes. At 020900Z the pressure began to fall rapidly as winds increased and rain showers became nearly continuous. Minimum pressure was reached at 021200Z, but the gradient between the low and the strong ridge to the north maintained gale force winds throughout the afternoon. Once again satellite data showed a possible circulation center developing on the east coast of Tunisia.

The third low pressure center in the Gulf of Gabes further increased the northeast gradient on the evening of 2 December. Between 1800Z and 2000Z the wind rarely decreased below

40 kt. Maximum strength was reached about 1840Z, with sustained winds of 48 kt gusting to 55 kt for about 15 minutes. After 1855Z, winds began to slowly diminish, settling in the 30-35 kt range until 030500Z, when they decreased to 20-25 kt with higher gusts in precipitation.

Southeasterly winds, which would precede passage of a North African low pressure system south of Tunis, present no problem to the port.

Temperatures at Tunis are generally mild during winter. January, the coldest month, has a mean daily maximum temperature of 58°F (14°C), and mean daily minimum of 44°F (7°C). The lowest recorded temperature at Tunis is 30°F (-1°C).

December, having 2.4 inches of rain falling during an average month, is the wettest month of the year with the rest of the winter months not far behind. See Figure 3-4.

B. Spring (March through May)

The early spring season is much the same as winter. See section 3.5.A above. The primary cause of strong northeasterly winds at Tunis, low pressure systems over the Tyrrhenian Sea which have their origins in the Gulf of Genoa, are active through the first part of the season, but become less frequent as the season progresses. North African lows, a second cause of strong northeasterly winds at Tunis, are at their yearly maximum frequency of occurrence during spring, but after April, the events become more infrequent. The cause of strong northwesterly winds at Tunis, the mistral over the Gulf of Lion, is observed through May.

Prevailing winds become easterly by the end of the spring. With the advent of warmer daytime temperatures late in the season, afternoon sea breezes become common, but local authorities state that they are light and present no problem to the port.

Temperatures increase significantly during spring. By May, daily maximum temperatures average 75°F (24°C), while daily minimums increase to 57°F (14°C). The mean highest temperature during May is 95°F (35°C).

Precipitation amounts decrease as the season progresses so that by May the average monthly accumulation is only 0.9 inches. See Figure 3-4.

C. Summer (June through September)

Summer weather is generally settled, with hot and dry conditions prevailing, and the more hazardous weather events occur only rarely. Prevailing winds are easterly. Cyclogenesis in the Gulf of Genoa is reduced so low pressure systems which transit the Tyrrhenian Sea and produce strong northeasterly winds at Tunis are uncommon. Strong mistral events in the Gulf of Lion do not normally occur from June through August so strong northwesterly winds are rare during most of the summer. North African low activity is also infrequent. By September, however, the possibility of strong mistral events over the Gulf of Lion increases, and the commensurate threat of strong northwesterly winds at Tunis also increases. Afternoon sea breezes are common at Tunis, but they are light and present no problem to the port.

Temperatures increase until July and August, the warmest months. The mean daily maximum temperature during August is 89°F (32°C), and the mean daily minimum is 70°F (21°C). The mean highest temperature during August is 109°F (43°C), while the absolute highest temperature on record at Tunis (through 1960) is 118°F (48°C).

July is the driest month with only 0.1 inch of precipitation falling during an average year. The combined average amounts for June, July, and August total only 0.8 inches. September sees a significant increase in precipitation with 1.1 inches accumulating during an average month. See Figure 3-4.

D. Autumn (October)

Autumn, a short, transitional season in the Mediterranean Basin, lasts only for the month of October. It results in an abrupt change from summer weather to the unsettled weather of winter (Brody and Nestor, 1980).

Cyclogenesis in the Gulf of Genoa increases as winter approaches. As Genoa lows (discussed in section 3.5.A above) move southeastward across the Tyrrhenian sea, the threat of strong northeasterly winds at the Port of Tunis also increases. A second cause of strong north-easterly winds at Tunis, North African lows (also discussed in section 3.5.A above) which move eastward south of the Atlas Mountains before moving into the central or eastern Mediterranean Sea, are increasingly frequent as winter approaches, but don't reach their maximum frequency of occurrence until late winter/spring.

Strong mistral events over the Gulf of Lion, with resultant strong northwesterly winds affecting the Port, are possible.

Temperatures moderate considerably during the month from the highs of summer. The mean daily maximum temperature is 76°F (24°C), and the mean daily minimum is 60°F (16°C). The mean highest temperature during

October is 92°F (33°C) and the mean lowest is 48°F (9°C).

Precipitation continues to increase from the low of mid-summer with 1.9 inches observed during an average month. See Figure 3-4.

3.6 Harbor Protection

3.6.1 Winds

Local authorities state that the harbor provides sufficient protection from strong northwesterly through north to northeasterly winds so that ships that are already in the harbor during episodes of high winds should remain there. However, ships in the anchorage are not protected, and may need to take protective measures to mitigate the effects of heavy weather. See section 3.7 below.

3.6.2 Waves

The harbor of La Goulette, which forms the entrance to Canal de Tunis, is a dredged channel leading to the port of Tunis. The harbor is protected from wave action by breakwaters, thus waves are not considered a problem. Deep draft vessels anchored seaward of the outer channel leading to La Goulette harbor are exposed to heavy wave (13-16 ft) action (FICEURLANT, 1985). Wave energy in this portion of the Mediterranean Sea is generally at a maximum around 6 second periods. Note that this is at much shorter periods than in the eastern Mediterranean. The most frequent source of waves are from the Tyrrhenian Sea where fetch lengths are limited to a couple hundred n mi. Waves from this area are generally limited to 7 to 10 ft heights. When strong mistrals, which have a longer fetch length occur, northwesterly swell with maximum energy around 12 second period is experienced. These (largely winter season) northwesterly longer period swell waves result in confused wave directions in the Bay of Tunis due to reflection off the southeast coast of the Bay back to the anchorage and harbor entrance areas. These confused seas coupled with the restricted channel and low speed requirements can cause steerage problems for ships entering or leaving the harbor.

Because of the shoal conditions in the Bay of Tunis deep draft ships are required to anchor 4 to 5 n mi or more seaward of the harbor. Therefore special consideration must be given to the effect on small vessels of the concentration of wave energy in the lower period waves. While longer vessels may be riding smoothly the small vessels may be experiencing dangerous conditions due to their maximum response to short period waves. The confused seas associated with the longer period northwesterly swell can present special problems for various size vessels when working alongside as well as for small boat operations.

Table 3-1 provides the shallow water wave conditions for the anchorage area, designated point 1 on Figure 3-2, when deep water swell enters the area.

Example: Use of Table 3-1.
For a deep water wave condition of 16 feet, 12 seconds, from 330°, the approximate shallow water wave conditions are:
Point 1: 9-10 feet, 12 seconds, from 020°

Table 3-1. Shallow water wave directions and relative height conditions versus deep water period and direction (see Figure 3-3 for location of point 1).

FORMAT: Shallow Water Direction
Wave Height Ratio: (Shallow Water/Deep Water)

TUNIS POINT 1: Anchorage Depth 45 ft

Period (sec)	6	8	10	12	14
Deep Water Direction	Shallow Water Direction and Height Ratio				
360°*	360° .5	360° .5	010° .6	020° .6	020° .5
030°	030° 1.0	030° .9	030° .8	035° .8	035° .8
060°	060° .5	055° .4	050° .2	045° .15	035° .2

*Note: Mistral generated northwesterly waves over the open Mediterranean Sea must be refracted to become northerly swell after entering the Gulf of Tunis in order to reach the anchorage area.

Situation-specific shallow water wave conditions resulting from deep water wave propagation are given in Table 3-1, while the seasonal climatology of wave conditions in the harbor resulting from the propagation of deep water waves into the harbor are given in Table 3-2. If the actual or forecast deep water wave conditions are known, the expected conditions at the specified harbor area can be determined from Table 3-1. The mean duration of the condition, based on the shallow water wave heights, can be obtained from Table 3-2.

Example: Use of Tables 3-1 and 3-2.

The forecast for wave conditions tomorrow (winter case) outside the harbor are:
10 feet, 6 seconds, from 030°

Expected shallow water conditions and duration:

	Point 1
Height	10 feet
Period	6 seconds
Direction	from 030°
Duration	16 hours

Interpretation of the information from Tables 3-1 and 3-2 provides guidance on the local wave conditions expected tomorrow at the specified area point. The duration values are mean values for the specified height range and season. Knowledge of the current synoptic pattern and forecast/expected duration should be used when available.

Possible applications to small boat operations are selection of the mother ships anchorage point, and/or areas of small boat work. The condition duration information provides insight as to how long before a change can be expected. The local wave direction information can be of use in selecting anchorage configuration and related small boat operations including tending activities.

Table 3-2. Shallow water climatology as determined from deep water wave propagation. Percent occurrence, average duration or persistence, and wave period of maximum energy for wave height ranges of greater than 3.3 ft (1 m) and greater than 6.6 ft (2 m) by climatological season.

TUNIS POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	42	22	24	28
Average Duration (hr)	22	16	32	22
Period Max Energy(sec)	6	6	6	6
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	14	3	1	5
Average Duration (hr)	16	7	8	18
Period Max Energy(sec)	6*	6	6	6

*Note that in winter extreme wave heights of 13 to 16 ft at about 12-second periods occur during strong mistral events.

Local wind wave conditions are provided in Table 3-3 for a range of fetch lengths and wind speeds. The time to reach the fetch limited height assumes an initial flat ocean. With a pre-existing wave height, the times are shorter.

Table 3-3. Tunis. Local wind waves for fetch limited conditions (based on JONSWAP model).

Format: height (feet)/period (seconds)
time (hours) to reach fetch limited height

Fetch Length (n mi)	Local Wind Speed (kt) 18	24	30	36	42
5	<2 ft	2/3-4 1	2-3/3-4 1	3/3-4 1-2	3-4/3-4 1
10	2/3-4 1-2	3/3-4 2	3-4/4 2	4/4-5 1-2	5/5 1-2
15	2-3/4 2	3-4/4 2	4/4-5 2	5/5 2	6/5 2
20	3/4-5 2-3	4/4-5 3	5/5 3	6/5-6 3-4	7/5-6 3
25	3-4/4-5 3	4/5 3	5-6/5 3	6-7/6 3	7-8/6 3
30	4/4-5 3	5/5-6 4	6/6 3-4	7/6 3-4	8/6-7 3

Example: Small boat wave forecasts for a location that has a 5 n mi limited fetch to the east (based on the assumption that swell is not a limiting condition).

Forecast for Tomorrow:

Time	Wind (Forecast)	Waves (Table 3-3)
prior to 1000 LST	E 8-12 kt	< 2 ft
1000 to 1400	E 22-26 kt	2 ft at 3-4 sec by 1100
1400 to 1900	E 34-38 kt	building to 3 ft at 3-4 sec by 1500

Interpretation: Assuming that the limiting factor is waves greater than 3 feet, small boat operations will become marginal by 1500.

Combined wave heights are computed by finding the square root of the sum of the squares of the wind wave and swell heights. For example, if the wind waves were 3 ft and the swell 8 ft the combined height would be about 8.5 ft.

$$\sqrt{3^2 + 8^2} = \sqrt{9 + 64} = \sqrt{73} \approx 8.5$$

Note that the increased height is relatively small. Even if the two wave types were of equal height the combined heights are only 1.4 times the equal height. In cases where one or the other heights are twice that of the other, the combined height will only increase over the larger of the two by 1.12 times (10 ft swell and 5 ft wind wave combined results in 11.2 ft height).

3.6.3 Wave Data Uses and Considerations

Local wind waves build up quite rapidly and also decrease rapidly when winds subside. The period and, therefore, length of wind waves is generally short relative to the period and length of waves propagated into the harbor (see Appendix A). The shorter period and length result in wind waves being characterized by choppy conditions. When wind waves are superimposed on deep water waves propagated into shallow water, the waves can become quite complex and confused. Under such conditions, when waves from two or more sources are influencing a location, tending or joint operations can be hazardous even if the individual wave train heights are not significantly high. Vessels of various lengths respond with different motions to the diverse wave lengths present. The information on wave periods, provided in the previous tables, should be considered when forecasts are made for joint operations of various length vessels.

3.7 Protective and Mitigating Measures

During episodes of strong winds, ships moored in the harbor should remain in port and add/double mooring lines as necessary.

Using two anchors, ships in the anchorage should anchor with bow into the swell. If strong northeast winds are experienced, however, ships may have to sortie and ride the storm out at sea or seek shelter elsewhere. No nearby anchorage provides adequate protection from northeasterly conditions. Possible shelter from strong easterly winds exists in the lee of the peninsula east of the port, and shelter from strong northwesterly winds may be found south of Cape Farina, north of the port.

3.7.1 Moving to a New Anchorage

For ships anchored outside the harbor movement to any anchorage within the harbor will provide protection from waves. There are no truly protected anchorage areas within the Gulf or Bay of Tunis from northwesterly wind and waves. However, the closer vessels can approach the head of the Bay of Tunis the greater will be the protection from northwesterly winds and waves. Protection from easterly winds can be gained by moving to the eastern side of the Gulf or Bay. Vessels that cannot enter the harbor may have to sortie from the anchorage area during periods of extreme northwest through northeast wind/wave episodes. Steerage problems may exist when entering or leaving the harbor during periods of strong northwesterly winds and related confused wave conditions.

3.7.2 Scheduling

Wind and wave impacts on scheduling are related to synoptic scale events such as mistrals, cyclonic activity in the Tyrrenian Sea and North African lows passing eastward south of the area. In general, local effects do not result in hazardous conditions.

3.8 Local Indicators or Hazardous Weather Conditions

No local indicators are identified. Forecasters should be alert for the development of weather scenarios briefly addressed below and more thoroughly discussed in section 3.5.A above.

Northeast winds - A major cause of northeasterly winds Tunis results from cyclogenesis in the Gulf of Genoa. If high pressure exists over the Balkans, Turkey, and the Black Sea after the low is formed, the low will tend to move southeastward across the Tyrrhenian Sea and may produce strong northeasterly winds at Tunis.

North African lows also have the potential to cause strong north to northeasterly winds at Tunis as they move eastward into the Gulf of Gabes south of Tunis after forming south of the Atlas Mountains.

Northwest winds - Strong northwest winds occur two days after a strong mistral event is observed in the Gulf of Lion. It should be noted that the basic circulation that creates a mistral is also normally associated with Genoa cyclogenesis.

Another potential cause of strong northwesterly winds at Tunis is a North African low which moves northeastward across the coast of Tunisia toward Sicily. Strong winds are likely to the west of the northeastward tracking low especially when the low is accompanied by a tongue of cold air aloft (evident at 500 mb) (Brody and Nestor, 1980).

3.9 Summary of Problems, Actions, and Indicators

Table 3-4 is intended to provide easy-to-use seasonal references for forecasters on ships using the Port of Tunis. Table 2-1 (Section 2) summarizes Table 3-4 and is intended primarily for use by ship captains.

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Table 3-4. Potential problem situations at t

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EV
1. Moored - La Goulette. Most common in Winter & Spring, uncommon in Summer, possible in Autumn.	a. NE'ly winds/waves - Wind speeds of 34-47 kt (force 8-9) may be accompanied by waves of 7-10 ft (2-3 m). Strongest in spring.	a. Little adverse effect in the should remain in port, and add/d lines as necessary.

Table 3-4. Potential problem situations at the Port of Tunis, Tunisia - ALL SEASONS

POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND O ABOUT POTENTIAL HAZ
'ly winds/waves - Wind of 34-47 kt (force 8-9) accompanied by waves of t (2-3 m). Strongest in .	a. Little adverse effect in the harbor. Ships should remain in port, and add/double mooring lines as necessary.	a. NE'ly winds at Tunis may be over the Tyrrhenian Sea which in the Gulf of Genoa or lows w Africa. Genoa lows. Development factors. (1) contrast between land and sea, between the polar front jet st subtropical jet stream (3) ef over the Alps, enhancing cyclo along the S slopes, and (4) ef concave curvature of the S slo enhancing cyclonic formation. Development climatology. cyclogenesis can occur during although the region of maximum located farther S in winter th maximum density moves from the during the winter to the Po Va summer. If there is little or NE entering the Po Valley, cyc probably take place in the Gul Otherwise, the cyclogenesis wi its usual position to the W ne Genoa. Cyclone movement. A majo cyclones either remain station leave a residual trough, S of throughout their life history. anticyclone exists over the Ba the Black Sea, the favored tra the N border of the Mediterran the primary low has moved out Sea-Central Mediterranean area trough remains S of the Alps, develop and occasionally move coast of Italy. Another commo for a Genoa cyclone to become the W of S Italy. Along the W coast of Ital winds occur when the low moves Gale force NE winds are common conditions. Although the stro not reach Tunis, the situation gale force winds at the port. N African lows. N African the Mediterranean Sea through are also potential sources of N African lows develop over th of the Atlas mountains. The s favoring development is the pr trough lying over Spain with i SW, producing a deep SW'ly flo The presence of a cold front i immaterial for the development when one is present, developme before the front reaches the r

situations at the Port of Tunis, Tunisia - ALL SEASONS

UTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
effect in the harbor. Ships ort, and add/double mooring	a. NE'ly winds at Tunis may be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa or lows which form over N Africa. Genoa lows. Development factors. (1) The thermal contrast between land and sea, (2) interaction between the polar front jet stream and the subtropical jet stream (3) effect of N'ly flow over the Alps, enhancing cyclogenetic activity along the S slopes, and (4) effect of the concave curvature of the S slopes of the Alps, enhancing cyclonic formation. Development climatology. Genoa cyclogenesis can occur during all seasons, although the region of maximum cyclogenesis is located farther S in winter than in summer. The maximum density moves from the Gulf of Genoa during the winter to the Po Valley during the summer. If there is little or no cold air from NE entering the Po Valley, cyclogenesis will probably take place in the Gulf of Venice. Otherwise, the cyclogenesis will take place in its usual position to the W near the Gulf of Genoa. Cyclone movement. A majority of Genoa cyclones either remain stationary, or at least leave a residual trough, S of the Alps throughout their life history. If a strong anticyclone exists over the Balkans, Turkey and the Black Sea, the favored track is SE'ly near the N border of the Mediterranean Sea. After the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains S of the Alps, new centers can develop and occasionally move SE along the W coast of Italy. Another common occurrence is for a Genoa cyclone to become stationary just to the W of S Italy. Along the W coast of Italy, the strongest winds occur when the low moves off to the SE. Gale force NE winds are common under these conditions. Although the strongest winds may not reach Tunis, the situation could result in gale force winds at the port. N African lows. N African lows moving into the Mediterranean Sea through the Gulf of Gabes are also potential sources of strong NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range.

Table 3-4. (Continue

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EV
Most common in Winter & Spring, uncommon in Summer, possible in Autumn.	b. <u>NW'ly winds/waves</u> - Winds speeds of 34-47 kt may reach the port, and NW swell waves may enter the Gulf of Tunis and reflect off its SE coast.	b. Little adverse effect in the reflecting off SE coast of the effect maneuvering in the entra could reach ships moored to the should remain in port, and add/ lines as necessary.
Possible any season, but strongest events are most likely during autumn, winter and spring.	c. <u>E'ly winds</u> - Strong event may reach the harbor, but is not considered a major problem.	c. Little effect in the harbor. remain in port, and add/double necessary.
2. <u>Anchored</u>. Most common in Winter & Spring, uncommon in Summer, possible in Autumn.	a. <u>NE'ly winds/waves</u> - Wind speeds of 34-47 kt (force 8-9) may be accompanied by waves of 7-10 ft (2-3 m). Strongest in spring.	a. Strong event may dictate tha ride out the heavy weather at s permit, ship may be able to rem using 2 anchors and anchoring w swell. Deep draft vessels at a roadstead may experience consid action if the wind backs to the prevailing swells from the nort

Table 3-4. (Continued)

POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AN ABOUT POTENTIAL H
<u>NW'ly winds/waves</u> - Winds eds of 34-47 kt may reach the t, and NW swell waves may er the Gulf of Tunis and lect off its SE coast.	b. Little adverse effect in the harbor, but waves reflecting off SE coast of the Gulf of Tunis effect maneuvering in the entrance channel and could reach ships moored to the N pier. Ships should remain in port, and add/double mooring lines as necessary.	b. Strong NW winds can be a strong Mistral event occ Lion. The mistral is the combination of the follow basic circulation that cre gradient from W to E alon France, (2) a fall wind e air associated with the m as it approaches the S coa increasing the wind speed, increase caused by the or of the coastline, and (4) the open water resulting the braking effect of sur compared to the braking e strongest winds associate generally occur over the decreasing SE. However, producing severe mistrals associated strong wind re as N Africa.
<u>E'ly winds</u> - Strong event reach the harbor, but is not sidered a major problem.	c. Little effect in the harbor. Ships should remain in port, and add/double mooring lines as necessary.	c. E'ly winds may result situation that places hig with relatively lower pre the wind velocity depende gradient.
<u>NE'ly winds/waves</u> - Wind eds of 34-47 kt (force 8-9) be accompanied by waves of 0 ft (2-3 m). Strongest in ing.	a. *Strong event may* dictate that ship sortie and ride out the heavy weather at sea. If conditions permit, ship may be able to remain at anchor by using 2 anchors and anchoring with bow into swell. Deep draft vessels at anchor in the open roadstead may experience considerable wave/swell action if the wind backs to the south with prevailing swells from the north.	a. NE'ly winds at Tunis ma over the Tyrrhenian Sea wh in the Gulf of Genoa or lo Africa. <u>Genoa lows</u>. <u>Development factors</u>. contrast between land and between the polar front je subtropical jet stream (3) over the Alps, enhancing c along the S slopes, and (4 concave curvature of the S enhancing cyclonic format <u>Development climatol</u> cyclogenesis can occur du although the region of ma located farther S in wint maximum density moves fro during the winter to the summer. If there is litt NE entering the Po Valley probably take place in th Otherwise, the cyclogenes its usual position to the Genoa.

(Continued)

TIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
fect in the harbor, but waves ast of the Gulf of Tunis n the entrance channel and ored to the N pier. Ships t, and add/double mooring	b. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France, (2) a fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed, (3) a jet-effect wind increase caused by the orographic configuration of the coastline, and (4) a wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa.
the harbor. Ships should add/double mooring lines as	c. E'ly winds may result from any synoptic situation that places high pressure N of Tunis with relatively lower pressure to the S, with the wind velocity dependent on the pressure gradient.
dictate that ship sortie and weather at sea. If conditions able to remain at anchor by anchoring with bow into essels at anchor in the open ence considerable wave/swell acks to the south with om the north.	a. NE'ly winds at Tunis may be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa or lows which form over N Africa. Genoa lows. Development factors. (1) The thermal contrast between land and sea, (2) interaction between the polar front jet stream and the subtropical jet stream (3) effect of N'ly flow over the Alps, enhancing cyclogenetic activity along the S slopes, and (4) effect of the concave curvature of the S slopes of the Alps, enhancing cyclonic formation. Development climatology. Genoa cyclogenesis can occur during all seasons, although the region of maximum cyclogenesis is located farther S in winter than in summer. The maximum density moves from the Gulf of Genoa during the winter to the Po Valley during the summer. If there is little or no cold air from NE entering the Po Valley, cyclogenesis will probably take place in the Gulf of Venice. Otherwise, the cyclogenesis will take place in its usual position to the W near the Gulf of Genoa.

Table 3-4. (Conti

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONAR
Most common in Winter & Spring, uncommon in Summer, possible in Autumn.	b. NW'ly winds/waves - Winds speeds of 34-47 kt may reach the port, and NW swell waves may enter the Gulf of Tunis and reflect off its SE coast.	b. Ships should be able to r using 2 anchors and anchorin swell. If strong event dict shelter may be found N of Tu Cape Farina, or along the co Hammamet.
Possible any season, but strongest events are most likely during autumn, winter and spring.	c. E'ly winds - Strong event may reach the port and pose problems for ships in the anchorage.	c. A strong event may dictat the E part of the Gulf of Tu advantage of the lee of the port.

Table 3-4. (Continued)

POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AN[D] ABOUT POTENTIAL H[A]
		Cyclone movement. A m cyclones either remain stat leave a residual trough, S throughout their life histo anticyclone exists over the the Black Sea, the favored the N border of the Mediter the primary low has moved o Sea-Central Mediterranean a trough remains S of the Alp develop and occasionally mo coast of Italy. Another co for a Genoa cyclone to beco the W of S Italy. Along the W coast of I winds occur when the low mo Gale force NE winds are com conditions. Although the s not reach Tunis, the situat gale force winds at the por N African lows. N Afric the Mediterranean Sea throu are also potential sources N African lows develop over of the Atlas mountains. Th favoring development is the trough lying over Spain wit SW, producing a deep SW'ly The presence of a cold fron immaterial for the developm when one is present, develo before the front reaches th
'ly winds/waves - Winds of 34-47 kt may reach the and NW swell waves may the Gulf of Tunis and off its SE coast.	b. Ships should be able to remain in anchorage by using 2 anchors and anchoring with bow into swell. If strong event dictates a sortie, shelter may be found N of Tunis in the lee of Cape Farina, or along the coast N of the Gulf of Hammamet.	b. Strong NW winds can be e a strong Mistral event occu Lion. The mistral is the r combination of the followin basic circulation that crea gradient from W to E along France, (2) a fall wind eff air associated with the mis as it approaches the S coas increasing the wind speed, increase caused by the orog of the coastline, and (4) a the open water resulting fr the braking effect of surfa compared to the braking eff strongest winds associated generally occur over the G decreasing SE. However, s producing severe mistrals associated strong wind regi as N Africa.
'y winds - Strong event ach the port and pose rs for ships in the age.	c. A strong event may dictate that ship move to the E part of the Gulf of Tunis and take advantage of the lee of the peninsula E of the port.	c. E'ly winds may result f situation that places high with relatively lower press the wind velocity dependent gradient.

-4. (Continued)

THE RD	UTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
rity ary, the A If kans ck is ean S of th , if new c SE al n occ stati y, th off unde ngest coul lows the C stron e des ynop esen ts ax w ov s ap of a nt us ounta		<u>Cyclone movement</u>. A majority of Genoa cyclones either remain stationary, or at least leave a residual trough, S of the Alps throughout their life history. If a strong anticyclone exists over the Balkans, Turkey and the Black Sea, the favored track is SE'ly near the N border of the Mediterranean Sea. After the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains S of the Alps, new centers can develop and occasionally move SE along the W coast of Italy. Another common occurrence is for a Genoa cyclone to become stationary just to the W of S Italy. Along the W coast of Italy, the strongest winds occur when the low moves off to the SE. Gale force NE winds are common under these conditions. Although the strongest winds may not reach Tunis, the situation could result in gale force winds at the port. <u>N African lows</u>. N African lows moving into the Mediterranean Sea through the Gulf of Gabes are also potential sources of strong NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range.
cted in th lt o facto a p coas caus l mov of Fra a j hic c nd i the frict over h a of L tic s ofte s ext	able to remain in anchorage by anchoring with bow into event dictates a sortie, nd N of Tunis in the lee of the coast N of the Gulf of	b. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France, (2) a fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed, (3) a jet-effect wind increase caused by the orographic configuration of the coastline, and (4) a wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa.
any ssur to the	may dictate that ship move to Gulf of Tunis and take lee of the peninsula E of the	c. E'ly winds may result from any synoptic situation that places high pressure N of Tunis with relatively lower pressure to the S, with the wind velocity dependent on the pressure gradient.

Table 3-4. (Cont

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONAR
3. Arriving/ departing. Most common in Winter & Spring, uncommon in Summer, possible in Autumn.	a. NE'ly winds/waves - Wind speeds of 34-47 kt (force 8-9) may be accompanied by waves of 7-10 ft (2-3 m). Strongest in spring.	a. Inbound vessels should c sea until conditions in the entering. No nearby havens harbor can be hampered by h vessels should get underway or stay in port until condi section 2.a above.

ɛd)

Table 3-4. (Continued)

VASI	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS ABOUT POTEN
.der r 't aba .st. winds .or to ıs aba	NE'ly winds/waves - Wind ds of 34-47 kt (force 8-9) be accompanied by waves of ft (2-3 m). Strongest in ng.	a. Inbound vessels should consider remaining at sea until conditions in the port abate before entering. No nearby havens exist. Entry to the harbor can be hampered by high winds. Outbound vessels should get underway prior to wind onset or stay in port until conditions abate. See section 2.a above.	a. NE'ly winds at Tuni over the Tyrrhenian Se in the Gulf of Genoa o Africa. Genoa lows. Development facto contrast between land between the polar fron subtropical jet stream over the Alps, enhanci along the S slopes, an concave curvature of t enhancing cyclonic for Development clima cyclogenesis can occur although the region of located farther S in w maximum density moves during the winter to t summer. If there is l NE entering the Po Val probably take place in Otherwise, the cycloge its usual position to Genoa. Cyclone movement. cyclones either remain leave a residual troug throughout their life anticyclone exists ove the Black Sea, the fav the N border of the Me the primary low has mo Sea-Central Mediterran trough remains S of th develop and occasional coast of Italy. Anoth for a Genoa cyclone to the W of S Italy. Along the W coast winds occur when the l Gale force NE winds ar conditions. Although not reach Tunis, the s gale force winds at th N African lows. N the Mediterranean Sea are also potential sou N African lows develop of the Atlas mountains favoring development i trough lying over Spai SW, producing a deep S The presence of a cold immaterial for the dev when one is present, d before the front reach

1. (Continued)

...TIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
...should consider remaining at ... in the port abate before ... havens exist. Entry to the ...ed by high winds. Outbound ...nderway prior to wind onset ...l conditions abate. See	a. NE'ly winds at Tunis may be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa or lows which form over N Africa. <u>Genoa lows</u>. <u>Development factors</u>. (1) The thermal contrast between land and sea, (2) interaction between the polar front jet stream and the subtropical jet stream (3) effect of N'ly flow over the Alps, enhancing cyclogenetic activity along the S slopes, and (4) effect of the concave curvature of the S slopes of the Alps, enhancing cyclonic formation. <u>Development climatology</u>. Genoa cyclogenesis can occur during all seasons, although the region of maximum cyclogenesis is located farther S in winter than in summer. The maximum density moves from the Gulf of Genoa during the winter to the Po Valley during the summer. If there is little or no cold air from NE entering the Po Valley, cyclogenesis will probably take place in the Gulf of Venice. Otherwise, the cyclogenesis will take place in its usual position to the W near the Gulf of Genoa. <u>Cyclone movement</u>. A majority of Genoa cyclones either remain stationary, or at least leave a residual trough, S of the Alps throughout their life history. If a strong anticyclone exists over the Balkans, Turkey and the Black Sea, the favored track is SE'ly near the N border of the Mediterranean Sea. After the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains S of the Alps, new centers can develop and occasionally move SE along the W coast of Italy. Another common occurrence is for a Genoa cyclone to become stationary just to the W of S Italy. Along the W coast of Italy, the strongest winds occur when the low moves off to the SE. Gale force NE winds are common under these conditions. Although the strongest winds may not reach Tunis, the situation could result in gale force winds at the port. <u>N African lows</u>. N African lows moving into the Mediterranean Sea through the Gulf of Gabes are also potential sources of strong NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range.

Table 3-4. (Con

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTION
Most common in Winter & Spring, uncommon in Summer, possible in Autumn.	b. NW'ly winds/waves - Winds speeds of 34-47 kt may reach the port, and NW swell waves may enter the Gulf of Tunis and reflect off its SE coast.	b. Inbound and outbound v steerage difficulties in to the effects of wave re coast of the Gulf of Tuni harbor can be hampered by section 2.b above.
Possible any season, but strongest events are most likely during autumn, winter and spring.	c. E'ly winds - Strong event may reach the harbor, but is not considered a major problem. The same winds may cause problems for ships in the anchorage. Maneuvering in the channel may be affected.	c. No major problems are harbor. A strong event i inbound to the anchorage the Gulf of Tunis to tak the peninsula E of the p
4. Small boats. Most common in Winter & Spring, uncommon in Summer, possible in Autumn.	a. NE'ly winds/waves - Wind speeds of 34-47 kt (force 8-9) may be accompanied by waves of 7-10 ft (2-3 m). Strongest in spring.	a. No significant proble runs to/from the anchora curtailed in a strong eve

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Table 3-4. (Continued)

Y/EVA	OTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS / ABOUT POTENTIAL
els may entrar ction c Entry gh winc	ly winds/waves - Winds of 34-47 kt may reach the nd NW swell waves may he Gulf of Tunis and off its SE coast.	b. Inbound and outbound vessels may encounter steerage difficulties in the entrance channel due to the effects of wave reflection off of the SE coast of the Gulf of Tunis. Entry into the harbor can be hampered by high winds. See section 2.b above.	b. Strong NW winds can b a strong Mistral event c Lion. The mistral is th combination of the follc basic circulation that c gradient from W to E alc France, (2) a fall wind air associated with the as it approaches the S c increasing the wind spee increase caused by the c of the coastline, and (4 the open water resulting the braking effect of su compared to the braking strongest winds associat generally occur over the decreasing SE. However, producing severe mistral associated strong wind r as N Africa.
entifie dictat ve to t dvantag .	y winds - Strong event ch the harbor, but is not red a major problem. The nds may cause problems ps in the anchorage. ring in the channel may cted.	c. No major problems are identified in the harbor. A strong event may dictate that ships inbound to the anchorage move to the E part of the Gulf of Tunis to take advantage of the lee of the peninsula E of the port.	c. E'ly winds may resul situation that places hi with relatively lower pr the wind velocity depenc gradient.
in the may hav .	ly winds/waves - Wind of 34-47 kt (force 8-9) accompanied by waves of (2-3 m). Strongest in	a. No significant problems in the harbor, but runs to/from the anchorage may have to be curtailed in a strong event.	a. NE'ly winds at Tunis over the Tyrrhenian Sea in the Gulf of Genoa or Africa. Genoa lows. Development factors contrast between land an between the polar front subtropical jet stream (over the Alps, enhancing along the S slopes, and concave curvature of the enhancing cyclonic forma Development climatc cyclogenesis can occur d although the region of m located farther S in wir maximum density moves fr during the winter to the summer. If there is lit NE entering the Po Valle probably take place in t Otherwise, the cyclogene its usual position to th Genoa.

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AUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
bound vessels may encounter ies in the entrance channel due wave reflection off of the SE of Tunis. Entry into the ered by high winds. See	b. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France, (2) a fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed, (3) a jet-effect wind increase caused by the orographic configuration of the coastline, and (4) a wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa.
rs are identified in the vent may dictate that ships nrage move to the E part of take advantage of the lee of the port.	c. E'ly winds may result from any synoptic situation that places high pressure N of Tunis with relatively lower pressure to the S, with the wind velocity dependent on the pressure gradient.
blems in the harbor, but rrage may have to be ong event.	a. NE'ly winds at Tunis may be caused by lows over the Tyrrhenian Sea which have their origins in the Gulf of Genoa or lows which form over N Africa. Genoa lows. Development factors. (1) The thermal contrast between land and sea, (2) interaction between the polar front jet stream and the subtropical jet stream (3) effect of N'ly flow over the Alps, enhancing cyclogenetic activity along the S slopes, and (4) effect of the concave curvature of the S slopes of the Alps, enhancing cyclonic formation. Development climatology. Genoa cyclogenesis can occur during all seasons, although the region of maximum cyclogenesis is located farther S in winter than in summer. The maximum density moves from the Gulf of Genoa during the winter to the Po Valley during the summer. If there is little or no cold air from NE entering the Po Valley, cyclogenesis will probably take place in the Gulf of Venice. Otherwise, the cyclogenesis will take place in its usual position to the W near the Gulf of Genoa.

Table 3-4. (Continu

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EV
Most common in Winter & Spring, uncommon in Summer, possible in Autumn.	b. <u>NW'ly winds/waves</u> - Winds speeds of 34-47 kt may reach the port, and NW swell waves may enter the Gulf of Tunis and reflect off its SE coast.	b. No significant problems in t runs to/from the anchorage may curtailed in a strong event.
Possible any season, but strongest events are most likely during autumn, winter and spring.	c. <u>E'ly winds</u> - Strong event may reach the port, but is not considered a major problem.	c. No significant problems in t runs to/from the anchorage may curtailed in a strong event.

Table 3-4. (Continued)

V:	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS ANI ABOUT POTENTIAL H/
			Cyclone movement. A m cyclones either remain stat leave a residual trough, S throughout their life histo anticyclone exists over the the Black Sea, the favored the N border of the Mediter the primary low has moved o Sea-Central Mediterranean a trough remains S of the Alp develop and occasionally mo coast of Italy. Another co for a Genoa cyclone to beco the W of S Italy. Along the W coast of I winds occur when the low mo Gale force NE winds are com conditions. Although the s not reach Tunis, the situat gale force winds at the por N African lows. N Afric the Mediterranean Sea throu are also potential sources N African lows develop over of the Atlas mountains. Th favoring development is the trough lying over Spain wit SW, producing a deep SW'ly The presence of a cold fron immaterial for the developm when one is present, develo before the front reaches th
ha ve	NW'ly winds/waves - Winds eds of 34-47 kt may reach the and NW swell waves may er the Gulf of Tunis and ect off its SE coast.	b. No significant problems in the harbor, but runs to/from the anchorage may have to be curtailed in a strong event.	b. Strong NW winds can be e a strong Mistral event occu Lion. The mistral is the r combination of the followin basic circulation that crea gradient from W to E along France, (2) a fall wind eff air associated with the mis as it approaches the S coas increasing the wind speed, increase caused by the oroc of the coastline, and (4) a the open water resulting fr the braking effect of surfa compared to the braking ef1 strongest winds associated generally occur over the Gu decreasing SE. However, sy producing severe mistrals v associated strong wind regi as N Africa.
hai e t	'ly winds - Strong event reach the port, but is not sidered a major problem.	c. No significant problems in the harbor, but runs to/from the anchorage may have to be curtailed in a strong event.	c. E'ly winds may result i situation that places high with relatively lower pres: the wind velocity dependent gradient.

3-4. (Continued)

...UTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
	<u>Cyclone movement</u>. A majority of Genoa cyclones either remain stationary, or at least leave a residual trough, S of the Alps throughout their life history. If a strong anticyclone exists over the Balkans, Turkey and the Black Sea, the favored track is SE'ly near the N border of the Mediterranean Sea. After the primary low has moved out of the Tyrrhenian Sea-Central Mediterranean area, if a residual trough remains S of the Alps, new centers can develop and occasionally move SE along the W coast of Italy. Another common occurrence is for a Genoa cyclone to become stationary just to the W of S Italy. Along the W coast of Italy, the strongest winds occur when the low moves off to the SE. Gale force NE winds are common under these conditions. Although the strongest winds may not reach Tunis, the situation could result in gale force winds at the port. <u>N African lows</u>. N African lows moving into the Mediterranean Sea through the Gulf of Gabes are also potential sources of strong NE winds. N African lows develop over the desert region S of the Atlas mountains. The synoptic situation favoring development is the presence of an upper trough lying over Spain with its axis lying NE-SW, producing a deep SW'ly flow over NW Africa. The presence of a cold front is apparently immaterial for the development of a low, but when one is present, development usually occurs before the front reaches the mountain range.
...problems in the harbor, but ...nchorage may have to be ...ong event.	b. Strong NW winds can be expected 2 days after a strong Mistral event occurs in the Gulf of Lion. The mistral is the result of a combination of the following factors: (1) The basic circulation that creates a pressure gradient from W to E along the coast of S France, (2) a fall wind effect caused by cold air associated with the mistral moving downslope as it approaches the S coast of France and thus increasing the wind speed, (3) a jet-effect wind increase caused by the orographic configuration of the coastline, and (4) a wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land). The strongest winds associated with a mistral generally occur over the Gulf of Lion, decreasing SE. However, synoptic situations producing severe mistrals will often produce associated strong wind regimes extending as far as N Africa.
...problems in the harbor, but ...chorage may have to be ...ong event.	c. E'ly winds may result from any synoptic situation that places high pressure N of Tunis with relatively lower pressure to the S, with the wind velocity dependent on the pressure gradient.

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PORT VISIT INFORMATION

JANUARY 1990. NOARL Meteorologists R. Fett and Lieutenant M. Evans, U.S. Navy, met with Port Captain Mr. Mohamed Azzabou to obtain much of the information included in this port evaluation.

APPENDIX A

General Purpose Oceanographic Information

This section provides general information on wave forecasting and wave climatology as used in this study. The forecasting material is not harbor specific. The material in paragraphs A.1 and A.2 was extracted from H.O. Pub. No. 603, Practical Methods for Observing and Forecasting Ocean Waves (Pierson, Neumann, and James, 1955). The information on fully arisen wave conditions (A.3) and wave conditions within the fetch region (A.4) is based on the JONSWAP model. This model was developed from measurements of wind wave growth over the North Sea in 1973. The JONSWAP model is considered more appropriate for an enclosed sea where residual wave activity is minimal and the onset and end of locally forced wind events occur rapidly (Thornton, 1986), and where waves are fetch limited and growing (Hasselmann, et al., 1976). Enclosed sea, rapid onset/subsiding local winds, and fetch limited waves are more representative of the Mediterranean waves and winds than the conditions of the North Atlantic from which data was used for the Pierson and Moskowitz (P-M) Spectra (Neumann and Pierson 1966). The P-M model refined the original spectra of H.O. 603, which over developed wave heights.

The primary difference in the results of the JONSWAP and P-M models is that it takes the JONSWAP model longer to reach a given height or fully developed seas. In part this reflects the different starting wave conditions. Because the propagation of waves from surrounding areas into semi-enclosed seas, bays, harbors, etc. is limited, there is little residual wave action following periods of locally light/calm winds and the sea surface is nearly flat. A local wind developed wave growth is therefore slower than wave growth in the open ocean where some residual wave action is generally always present. This slower wave development is a built in bias in the formulation of the JONSWAP model which is based on data collected in an enclosed sea.

A.1 Definitions

Waves that are being generated by local winds are called "SEA". Waves that have traveled out of the generating area are known as "SWELL". Seas are chaotic in period, height and direction while swell approaches a simple sine wave pattern as its distance from the generating area increases. An in-between state exists for a few hundred miles outside the generating area and is a condition that reflects parts of both of the above definitions. In the Mediterranean area, because its fetches and open sea expanses are limited, SEA or IN-BETWEEN conditions will prevail. The "SIGNIFICANT WAVE HEIGHT" is defined as the average value of the heights of the one-third highest waves. PERIOD and WAVE LENGTH refer to the time between passage of, and distances between, two successive crests on the sea surface. The FREQUENCY is the reciprocal of the period (f = 1/T) therefore as the period increases the frequency decreases. Waves result from the transfer of energy from the wind to the sea surface. The area over which the wind blows is known as the FETCH, and the length of time that the wind has blown is the DURATION. The characteristics of waves (height, length, and period) depend on the duration, fetch, and velocity of the wind. There is a continuous generation of small short waves from the time the wind starts until it stops. With continual transfer of energy from the wind to the sea surface the waves grow with the older waves leading the growth and spreading the energy over a greater range of frequencies. Throughout the growth cycle a SPECTRUM of ocean waves is being developed.

A.2 Wave Spectrum

Wave characteristics are best described by means of their range of frequencies and directions or their spectrum and the shape of the spectrum. If the spectrum of the waves covers a wide range of frequencies and directions (known as short-crested conditions), SEA conditions prevail. If the spectrum covers a narrow range of frequencies and directions (long crested conditions), SWELL conditions prevail. The wave spectrum depends on the duration of the wind, length of the fetch, and on the wind velocity. At a given wind speed and given state of wave development, each spectrum has a band of frequencies where most of the total energy is concentrated. As the wind speed increases the range of significant frequencies extends more and more toward lower frequencies (longer periods). The frequency of maximum energy is given in equation 1.1 where v is the wind speed in knots.

$$f_{max} = \frac{2.476}{v} \qquad (1.1)$$

The wave energy, being a function of height squared, increases rapidly as the wind speed increases and the maximum energy band shifts to lower frequencies. This results in the new developing smaller waves (higher frequencies) becoming less significant in the energy spectrum as well as to the observer. As larger waves develop an observer will pay less and less attention to the small waves. At the low frequency (high period) end the energy drops off rapidly, the longest waves are relatively low and extremely flat, and therefore also masked by the high energy frequencies. The result is that 5% of the upper frequencies and 3% of the lower frequencies can be cut-off and only the remaining frequencies are considered as the "significant part of the wave spectrum". The resulting range of significant frequencies or periods are used in defining a fully arisen sea. For a fully arisen sea the approximate average period for a given wind speed can be determined from equation (1.2).

$$\bar{T} = 0.285v \qquad (1.2)$$

Where v is wind speed in knots and $\bar{T}$ is period in seconds. The approximate average wave length in a fully arisen sea is given by equation (1.3).

$$\bar{L} = 3.41\ \bar{T}^2 \qquad (1.3)$$

Where $\bar{L}$ is average wave length in feet and $\bar{T}$ is average period in seconds.

The approximate average wave length of a fully arisen sea can also be expressed as:

$$\bar{L} = .67\text{"L"} \qquad (1.4)$$

where "L" = $5.12T^2$, the wave length for the classic sine wave.

A.3 Fully Arisen Sea Conditions

For each wind speed there are minimum fetch (n mi) and duration (hr) values required for a fully arisen sea to exist. Table A-1 lists minimum fetch and duration values for selected wind speeds, values of significant wave (average of the highest 1/3 waves) period and height, and wave length of the average wave during developing and fully arisen seas. The minimum duration time assumes a start from a flat sea. When pre-existing lower waves exist the time to fetch limited height will be shorter. Therefore the table duration time represents the maximum duration required.

Table A-1. Fully Arisen Deep Water Sea Conditions Based on the *JONSWAP* Model.

Wind Speed (kt)	Minimum Fetch/Duration (n mi) (hrs)	Sig Wave (H1/3 Period/Height (sec) (ft)	Wave Length (ft)[1,2] Developing/Fully /Arisen L X (.5) /L X (.67)
10	28 / 4	4 / 2	41 / 55
15	55 / 6	6 / 4	92 / 123
20	110 / 8	8 / 8	164 / 220
25	160 / 11	9 / 12	208 / 278
30	210 / 13	11 / 16	310 / 415
35	310 / 15	13 / 22	433 / 580
40	410 / 17	15 / 30	576 / 772

NOTES:

[1] Depth throughout fetch and travel zone must be greater than 1/2 the wave length, otherwise shoaling and refraction take place and the deep water characteristics of waves are modified.

[2] For the classic sine wave the wave length (L) equals 5.12 times the period (T) squared ($L = 5.12T^2$). As waves develop and mature to fully developed waves and then propagate out of the fetch area as swell there wave lengths approach the classic sine wave length. Therefore the wave lengths of developing waves are less than those of fully developed waves which in turn are less than the length of the resulting swell. The factor of .5 (developing) and .67 (fully developed) reflect this relationship.

A.4 Wave Conditions Within The Fetch Region

Waves produced by local winds are referred to as SEA. In harbors the local sea or wind waves may create hazardous conditions for certain operations. Generally within harbors the fetch lengths will be short and therefore the growth of local wind waves will be fetch limited. This implies that there are locally determined upper limits of wave height and period for each wind velocity. Significant changes in speed or direction will result in generation of a new wave group with a new set of height and period limits. Once a fetch limited sea reaches its upper limits no further growth will occur unless the wind speed increases.

Table A-2 provides upper limits of period and height for given wind speeds over some selected fetch lengths. The duration in hours required to reach these upper limits (assuming a start from calm and flat sea conditions) is also provided for each combination of fetch length and wind speed. Some possible uses of Table A-2 information are:

1) If the only waves in the area are locally generated wind waves, the Table can be used to forecast the upper limit of sea conditions for combinations of given wind speeds and fetch length.

2) If deep water swell is influencing the local area in addition to locally generated wind waves, then the Table can be used to determine the wind waves that will combine with the swell. Shallow water swell conditions are influenced by local bathymetry (refraction and shoaling) and will be addressed in each specific harbor study.

3) Given a wind speed over a known fetch length the maximum significant wave conditions and time needed to reach this condition can be determined.

Table A-2. Fetch Limited Wind Wave Conditions and Time Required to Reach These Limits (Based on JONSWAP Model). Enter the table with wind speed and fetch length to determine the significant wave height and period, and time duration needed for wind waves to reach these limiting factors. All of the fetch/speed combinations are fetch limited except the 100 n mi fetch and 18 kt speed.

<u>Format:</u> height (feet)/period (seconds)
duration required (hours)

Fetch Length (n mi) \ Wind Speed (kt)	18	24	30	36	42
10	2/3-4 1-2	3/3-4 2	3-4/4 2	4/4-5 1-2	5/5 1-2
20	3/4-5 2-3	4/4-5 3	5/5 3	6/5-6 3-4	7/5-6 3
30	3-4/5 3	5/5-6 4	6/6 3-4	7/6 3-4	8/6-7 3
40	4-5/5-6 4-5	5/6 4	6-7/6-7 4	8/7 4	9-10/7-8 3-4
100	5/6-7[1] 5-6	9/8 8	11/9 7	13/9 7	15-16/9-10 7

[1] 18 kt winds are not fetch limited over a 100 n mi fetch.

An example of expected wave conditions based on Table A-2 follows:

<u>WIND FORECAST OR CONDITION</u>

An offshore wind of about 24 kt with a fetch limit of 20 n mi (ship is 20 n mi from the coast) is forecast or has been occurring.

<u>SEA FORECAST OR CONDITION</u>

From Table A-2: If the wind condition is forecast to last, or has been occurring, for at least 3 hours:

Expect sea conditions of 4 feet at 4-5 second period to develop or exist. If the condition lasts less than 3 hours the seas will be lower. If the condition lasts beyond 3 hours the sea will not grow beyond that developed at the end of about 3 hours unless there is an increase in wind speed or a change in the direction that results in a longer fetch.

A.5 Wave Climatology

The wave climatology used in these harbor studies is based on 11 years of Mediterranean SOWM output. The MED-SOWM is discussed in Volume II of the U.S. Naval Oceanography Command Numerical Environmental Products Manual (1986). A deep water MED-SOWM grid point was selected as representative of the deep water wave conditions outside each harbor. The deep water waves were then propagated into the shallow water areas. Using linear wave theory and wave refraction computations the shallow water climatology was derived from the modified deep water wave conditions. This climatology does not include the local wind generated seas. This omission, by design, is accounted for by removing all wave data for periods less than 6 seconds in the climatology. These shorter period waves are typically dominated by locally generated wind waves.

A.6 Propagation of Deep Water Swell Into Shallow Water Areas

When deep water swell moves into shallow water the wave patterns are modified, i.e., the wave heights and directions typically change, but the wave period remains constant. Several changes may take place including shoaling as the wave feels the ocean bottom, refraction as the wave crest adjusts to the bathymetry pattern, changing so that the crest becomes more parallel to the bathymetry contours, friction with the bottom sediments, interaction with currents, and adjustments caused by water temperature gradients. In this work, only shoaling and refraction effects are considered. Consideration of the other factors are beyond the resources available for this study and, furthermore, they are considered less significant in the harbors of this study than the refraction and shoaling factors.

To determine the conditions of the deep water waves in the shallow water areas the deep water conditions were first obtained from the Navy's operational MED-SOWM wave model. The bathymetry for the harbor/area of interest was extracted from available charts and digitized for computer use. Figure A-1 is a sample plot of bathymetry as used in this project. A ray path refraction/shoaling program was run for selected combinations of deep water wave direction and period. The selection was based on the near deep water wave climatology and harbor exposure. Each study area requires a number of ray path computations. Typically there are 3 or 4 directions (at 30° increments) and 5 or 6 periods (at 2 second intervals) of concern for each area of study. This results in 15 to 24 plots per area/harbor. To reduce this to a manageable format for quick reference, specific locations within each study area were selected and the information was summarized and is presented in the specific harbor studies in tabular form.

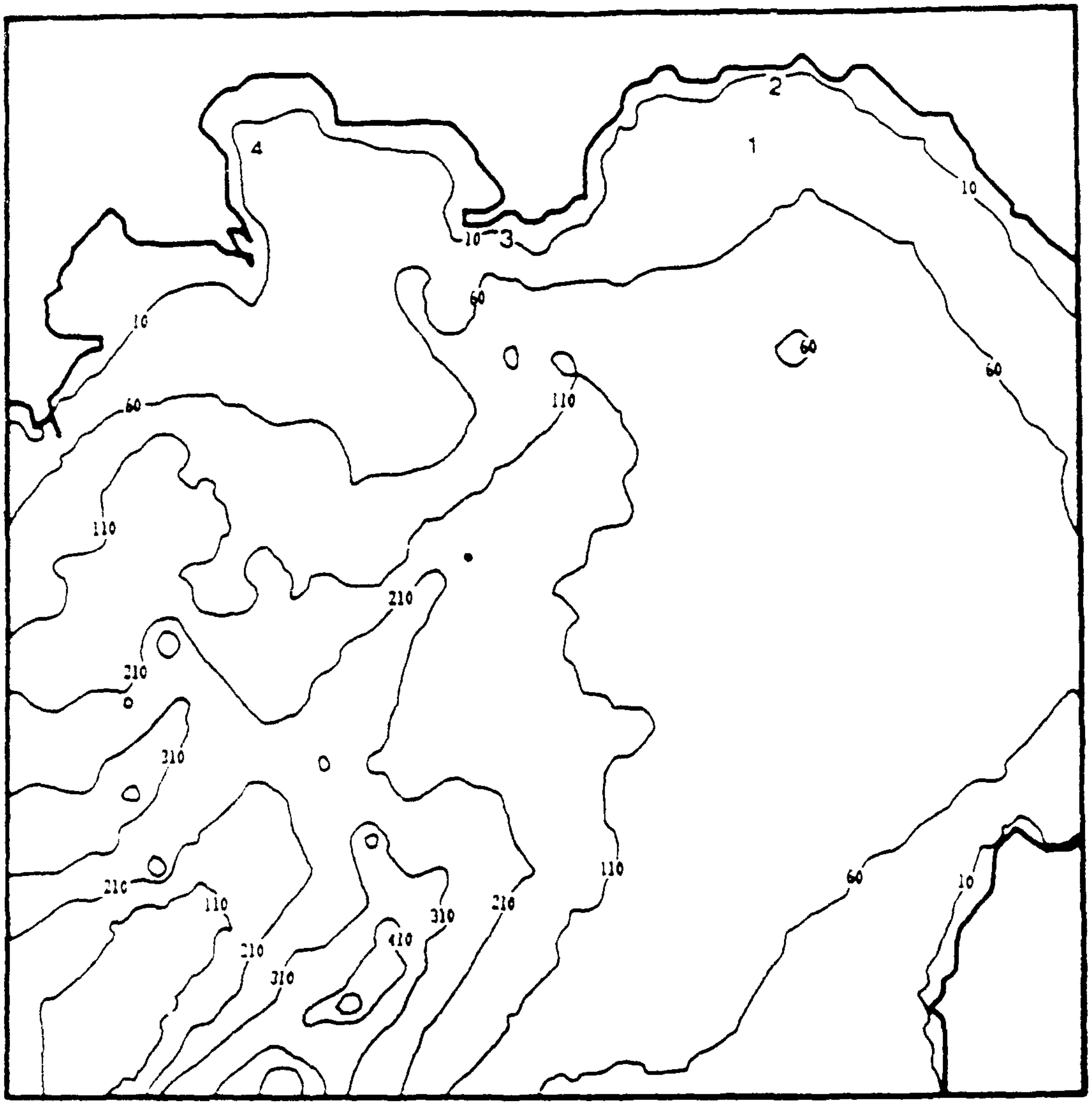

Figure A-1. Example plot of bathymetry (Naples harbor) as used in this project. For plotting purposes only, contours are at 50 fathom intervals from an initial 10 fathom contour. The larger size numbers identify specific anchorage areas addressed in the harbor study.

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205 Montecito Ave., Monterey, CA 93940

Naval Oceanographic and Atmospheric Research Laboratory,
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This handbook for the port of Tunis, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

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